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# Convective heat transfer from a cylinder in a strong acoustic field

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# NAVAL POSTGRADUATE SCHOOL
# MONTEREY, CALIFORNIA

# THESIS

## CONVECTIVE HEAT TRANSFER FROM A CYLINDER IN A STRONG ACOUSTIC FIELD

by

Donald R. Harder

December, 1995

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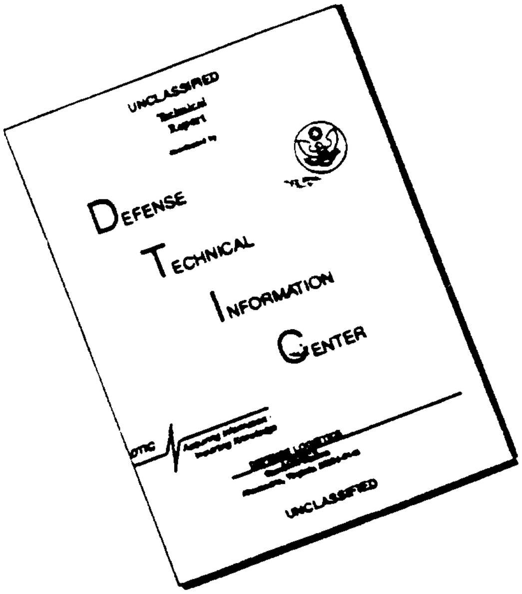

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# CONVECTIVE HEAT TRANSFER
# FROM A CYLINDER
# IN A STRONG ACOUSTIC FIELD

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# LIST OF SYMBOLS, ACRONYMS AND/OR ABBREVIATIONS

| | |
|---|---|
| $a$ | test cylinder radius [m] |
| $A$ | amplitude of particle oscillation [m] |
| $B$ | aspect ratio |
| $c$ | speed of sound [m/s] |
| $d$ | diameter of test cylinder [m] |
| $D$ | diameter of sound chamber [m] |
| $f$ | frequency [Hz] |
| Gr | Grashoff number |
| $h$ | convective heat transfer coefficient [W/m$^{2}$-K] |
| $I$ | current [Amps] |
| $k$ | thermal conductivity [W/m-K] |
| KC | Keulegan-Carpenter number |
| $l$ | length of test cylinder [m] |
| $L$ | distance from test cylinder to termination end plate [m] |
| $M$ | Mach number |
| Nu | Nusselt number |
| $P$ | power [W] |
| $P_m$ | mean ambient pressure [Pa] |
| $P_0$ | pressure level [Pa] |
| $P_{ref}$ | reference pressure [Pa] |
| PR | pressure ratio |
| $R$ | gas constant [J/kg-K] |
| $R_{eq}$ | equivalent thermal resistance [K/W] |
| $R_s$ | streaming Reynolds number |
| $S$ | pressure transducer sensitivity [mV/Pa] |
| SPL | sound pressure level [dB] |
| $T_a$ | ambient temperature [K] |
| $T_c$ | center temperature [K] |
| $T_s$ | surface temperature [K] |
| $U_0$ | particle velocity [m/s] |
| $V_0$ | voltage [Volts] |
| $Z$ | aspect ratio |
| $\beta$ | amplitude ratio |
| $\gamma$ | polytropic coefficient |
| $\delta$ | Stoke's boundary layer [m] |
| $\varepsilon$ | amplitude parameter |
| $\lambda$ | wavelength [m] |
| $\Lambda$ | frequency parameter |
| $\nu$ | kinematic viscosity [m$^{2}$/s] |
| $\chi$ | cylinder length scale |
| $\omega$ | radian frequency [rad/s] |

# I. INTRODUCTION

The science of convective heat transfer in an acoustic field, while still in its infancy, presents many new and exciting possibilities for application in the future. Different experiments and theory have proven that under the correct circumstances there are certain desirable heat transfer characteristics affecting an object which is immersed in a strong acoustic field. A complete analysis concerning the processes and effects of the related heat transfer phenomena, though, is lacking and desperately needed.

Although thermoacoustics have already been applied to some advanced heat transfer designs, for instance, the thermoacoustic space refrigerator and other thermoacoustic cryocoolers developed at the Naval Postgraduate School, there has yet to be developed anything that can compete on an economic level with what is currently marketed today. The efficiencies obtained so far have been quite low, requiring nearly twice the power of a conventional vapor compression refrigerator. When the fundamentals behind the thermoacoustic phenomenon and the related heat transfer characteristics are completely understood, breakthroughs can occur which could allow industry to move ahead and apply these techniques on an every day basis toward a variety of common uses.

To properly model and control the parameters which impact upon the heat transfer behavior in a thermoacoustic engine, it would be advantageous if the various flow regimes (e.g., turbulent vs. laminar) in the engine could be isolated and analyzed in detail. Further information in this regard may be obtained through a parametric analysis of a suitable model problem by which a measure of the importance (or rather a magnitude of the effect each parameter has on the process as a whole) can be determined. This is an important element of the modeling process and requires study since by understanding the impact that each individual parameter makes upon the thermoacoustic process as a whole, it may be possible to predict the changes in the heat transfer characteristics as individual components are varied.

The work contained within provides an experimental study of some of the dominant heat transfer properties of a particular model problem that may be encountered in thermoacoustic engines. The model problem chosen is one of convective heat transfer from a cylinder in a zero-mean oscillatory flow. The flow is representative of the acoustic standing wave in a thermoacoustic engine whereas the cylinder represents a tube or other component that may be present in such an engine.

The work involves a correlation of experimental heat transfer data in terms of a suitable Nusselt number (Nu) with other appropriate dimensionless parameters in the problem, such as the streaming Reynolds number ($R_s$), which itself is a function of length scales, pressure ratios and frequency parameters and, of course, of the Prandtl number (Pr). Through use of high power standing resonant acoustic waves in a cylindrical chamber, a high-intensity internal oscillatory flow is established. Under these conditions, the heat removal rate from a thin cylindrical heating element immersed in the acoustic signal will supply data necessary to arrive at some basic conclusions as to heat transfer phenomena occurring around a cylinder. This work focuses upon two different flow regimes; one in which laminar, attached flow around the cylinder at large values of the streaming Reynolds number is present, and the second in which vortex shedding and other instabilities in the flow are expected to occur at the cylinder surface. The resultant experimental data additionally provides guidelines for determining when the flow transitions from one regime to the other.

# II. BACKGROUND

## A. HISTORICAL

It has long been understood that a large temperature gradient along the length of a cylindrical tube can, under certain suitable circumstances, spontaneously excite the fluid into oscillations strong enough to create audible sound. Glass blowers provided the earliest accounts of this acoustic effect. They found that when one end of a glass tube was placed in a furnace, the temperature difference between the end of the tube in the furnace and the end still under ambient conditions created an audible tone which was emitted from the open end of the tube. Even though early scientists knew of this effect, it was merely considered to be more of an oddity than a scientific discovery which might have useful implications. In fact, the earliest accounting of what may have been the first ever thermoacoustic engine, the Sondhauss tube (Figure 1), was described by Sondhauss (1850) himself as the "glowing glass harmonica". Lord Rayleigh (1945) gave the first good qualitative analysis of the Sondhauss tube in 1896 in which he described the mechanism behind the effect and posed the theory that mechanical work could be obtained from the vibrations, or oscillations, which were being created by the temperature gradient along the tube.

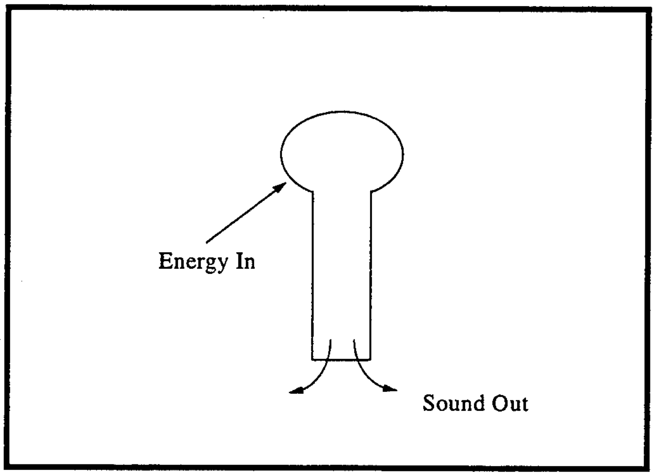

**Figure 1**. Sondhauss Tube

An extension of research into Sondhauss tubes was conducted by Carter (1988) and included placing a stack of plates at an appropriate point in the tube. The plates included hot heat exchanger strips at one end and cold heat exchanger strips at the other. These improved the effect of the Sondhauss tube, and inspired another scientist, Feldman (1966) to conduct similar research which consequently resulted in an oscillator which produced 27 W of acoustic power from 600 W of thermal power. All of this occurred in the 1960s.

It wasn't until much later that it was postulated that the effect could somehow be reversed, i.e., a temperature gradient could be created along a tube using a powerful, resonating acoustic signal as the driving force. It is only more recently that advances in acoustic technology have allowed serious research toward this goal.

## B. RECENT WORK

The heat transfer effect related to this thermoacoustic phenomenon has since been used in the creation of heat pumps and has been explored by several scientists. The results of these attempts include what was termed a pulse-tube refrigerator as developed by Gifford and Longsworth (1966). This refrigerator utilized low frequency, high amplitude oscillations to excite the gas in a tube and create a cooling effect along the surface. The invention of "modern" thermoacoustic refrigeration occurred in the early 1980s at Los Alamos National Laboratory. It was in essence a modification to the work that Carter did, using stacks of plates with a much smaller temperature gradient. Additional engineering developments by others, such as the work at the Naval Postgraduate School with a thermoacoustic refrigerator intended for use on the space shuttle, led to increases in efficiency, as well as to an increase in commercial interest and development. Currently, there are major projects ongoing in several countries as outlined by Swift (1995), including a prototype food refrigerator based upon the Naval Postgraduate School's work being built in the Republic of South Africa. The Ford Motor Company has developed its own version of a thermoacoustic refrigerator while the Tektronix Corporation is working towards a pulse-tube type of refrigerator to be used for cooling electronics to cryogenic temperatures.

All of these attempts are especially significant given the current stigma surrounding the environmentally hazardous use of CFC's. Even though thermoacoustic refrigeration is still not as efficient as that of current energy efficient vapor compression models, there is a growing demand for something to take their place. By advancing our knowledge-base in this area, and further incorporating a new understanding of how increases to the efficiency of thermoacoustic designs can be made, that it may well be possible that a new thermoacoustic revolution is in our future.

## C. THERMOACOUSTIC PROCESS

The basic process behind a thermoacoustic engine can be best described by the model in Figure 2. The upper portion of the figure shows a sound chamber with an acoustic driver at the left end which is used to create a resonant, standing wave in the chamber. At an appropriate point within the chamber, a thermoacoustic stack (Figure 3) is placed with a heat exchanger (Figure 4) on either side of it. The flow of heat is from right to left in the figure. The process of heat transport across the plate is illustrated in the lower portion of the figure. The fluid within the chamber will oscillate due to the acoustic wave, traveling from a point of low pressure to one of high pressure, gaining and losing energy during each half cycle.

For instance, a parcel of gas at temperature $T_0$ at low pressure moves along line 1, increasing in pressure and temperature until it reaches T++ (has gained two units of heat). At that point, it loses one unit of heat to the plate, thereby reducing its temperature to T+. As the parcel of gas continues through the second half of the oscillatory cycle, it decreases in pressure, and it loses two unit of heat, dropping to T-. It is then able to retrieve a single unit of heat from either the plate at the right hand side of the cycle, or from a heat exchanger at that end. In effect, a "bucket-brigade" of little parcels of gas is formed as the heat transport mechanism. It is the heat exchangers on either end of the thermoacoustic stack and the heat transport mechanisms involved with them that this experiment intends to analyze.

## D. HEAT TRANSFER IN ACOUSTIC FIELDS

The early 1950's saw an increased interest towards understanding the heat transfer behavior in oscillatory flows and an earnest effort towards understanding the possible benefits thereof began. Richardson (1967) produced the first significant contribution to this field by providing a coherent and detailed account on the general nature of heat transfer in oscillatory flows. He gave concise documentation on how sound and vibration fields had

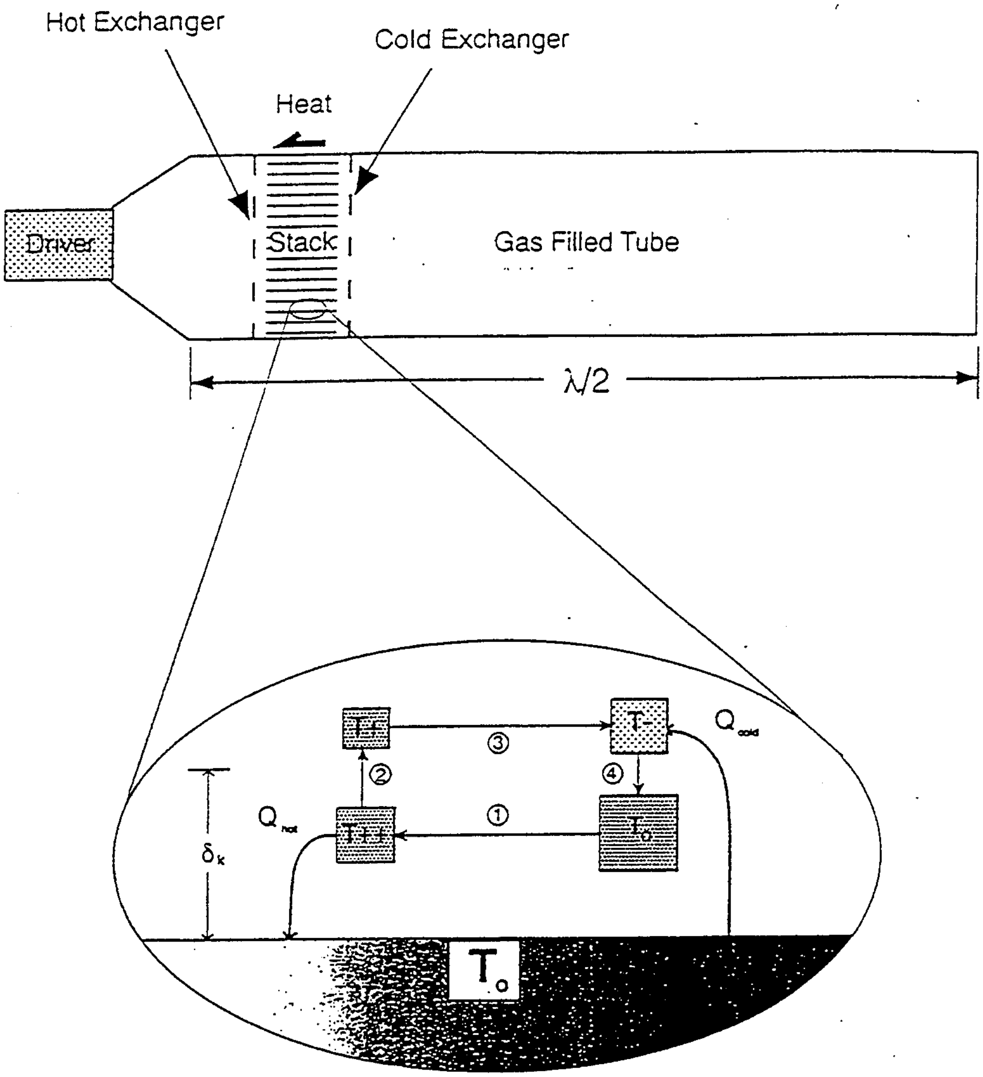

**Figure 2**. Basic Thermoacoustic Process.

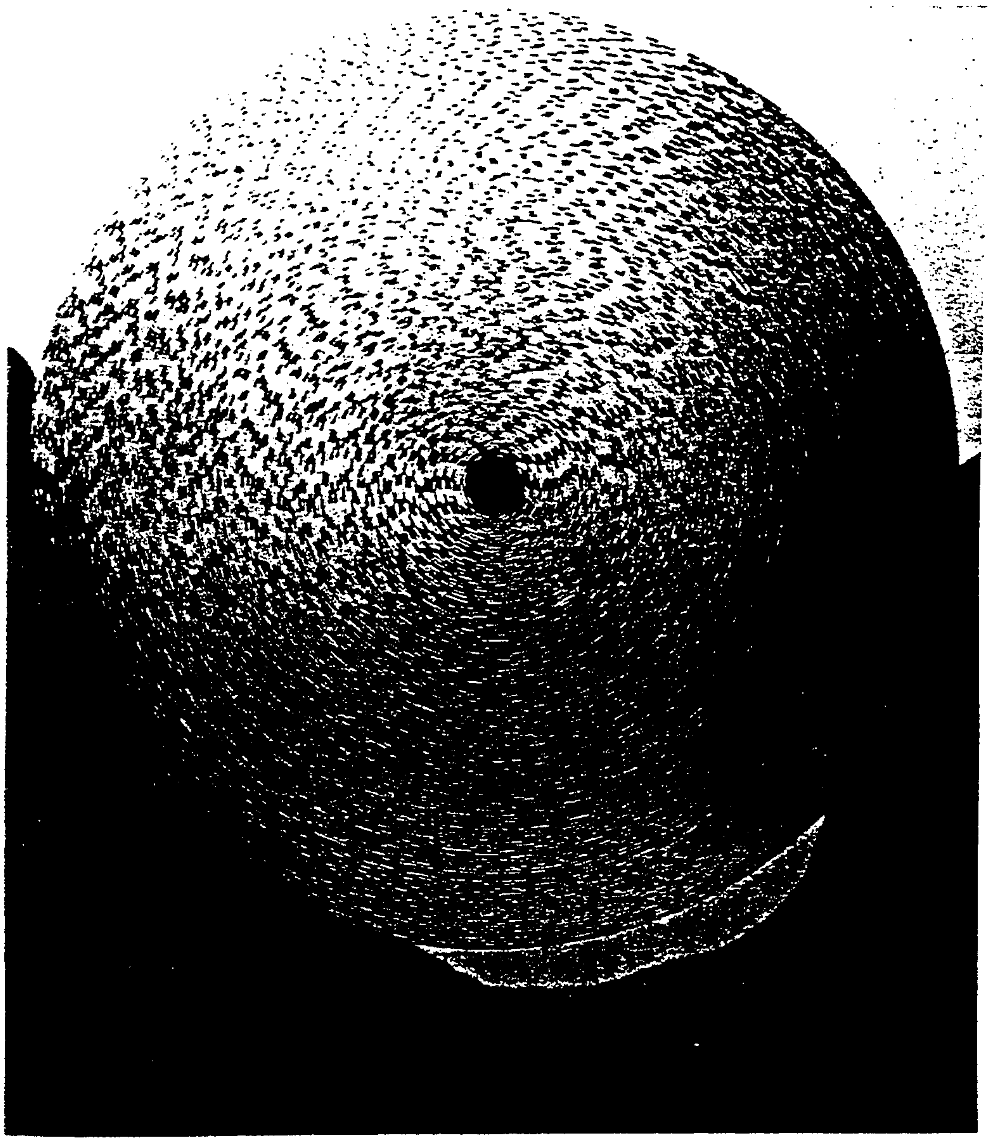

**Figure 3**. Thermoacoustic Stack.

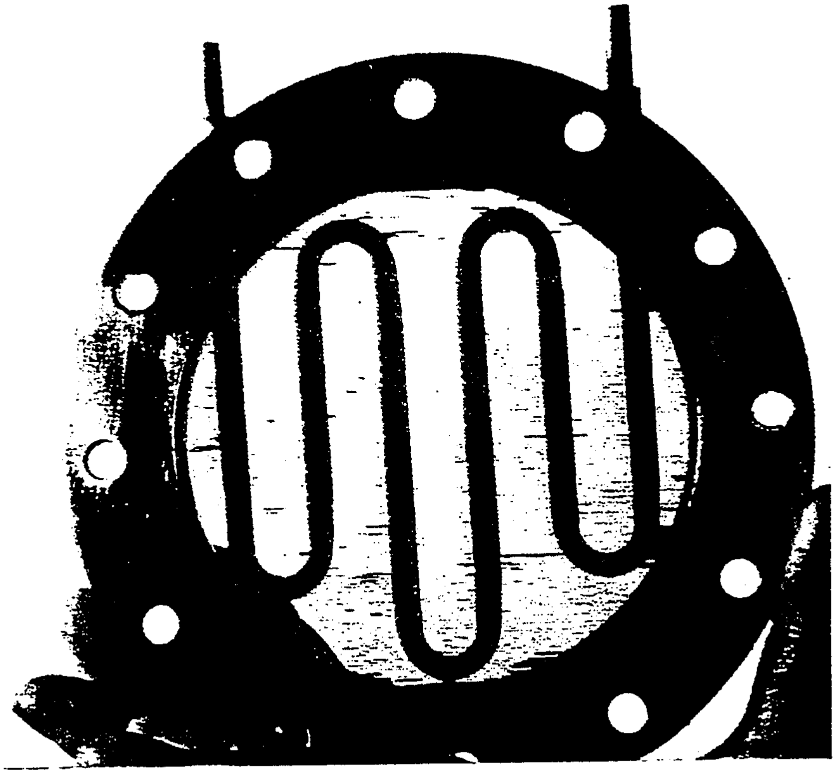

**Figure 4**. Heat Exchanger.

made an impact in the heat transfer field up to that point. He additionally conducted a preliminary study on how the effect can be related to that of a more traditional fluid-mechanical analysis. Davidson (1974) further expanded upon Richardson's work, analyzing the heat transfer behavior of cylinders in oscillatory flow. That occurred in the early 1970's, and since then, very little work on the subject can be found in literature.

Most recently, though, Mozurkewich (1995) performed heat transfer experiments in an acoustic field utilizing a transient analysis of a heated wire. His results, although informative in some respects, were lacking in data within the most basic flow regimes and his conclusions left some doubt to the reader.

When first attempting to analyze the process behind convective heat transfer in an acoustic field, it is often simpler to think of the heat transfer phenomenon as something akin to that of forced convection due to a steady mean flow. Initially, that there is a separate power source placed away from the test object which produces a disturbance in the fluid medium in which that object is immersed. In forced convection, that power source may be considered to be a fan or a pump which creates a pressure gradient, which in turn causes a steady flow of fluid. In the current problem, the power source is instead an acoustic driver which causes an oscillatory (or vibrational) type of time-periodic flow around the object being considered. This oscillatory flow has a zero-mean and results in no net through flow. Before analyzing this flow for heat transfer characteristics, though, it is necessary to first note which aspects of the acoustic field dominate.

A resonant, standing wave acoustic field excited across the ends of a closed cylindrical chamber has very distinct properties. Of particular interest is the fact that when such a field exists, the pressure along the length of the chamber varies sinusoidally such that a point of maximum pressure occurs at the rigid end termination at the opposite end of the chamber from which the acoustic signal is being generated. In addition, depending upon the frequency being used, there may be more than one zero-crossing, or pressure minimum, along the length of the chamber (Figure 5).

At resonance, the acoustic velocity is out of phase with the pressure. For instance, at a point of minimum pressure, a pressure node, the particle oscillations will be at their point of maximum velocity, a velocity antinode. The reverse then also holds true, (i.e., a pressure antinode can also be designated a velocity node).

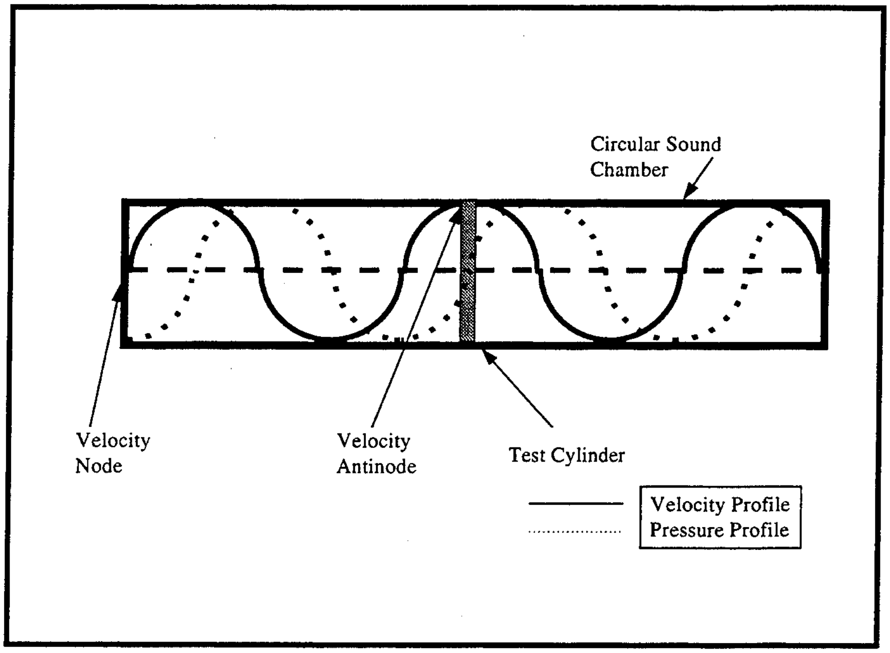

**Figure 5**. Pressure and Velocity Profiles in a Circular Tube in the Presence of an Acoustic Signal.

To understand the reason why this relationship is extremely valuable to this research, it is useful to again refer to the forced convection model. In general, as the fluid velocity in a forced convection application increases within a particular regime, so does the heat transfer coefficient. The case is essentially the same for heat transfer in an acoustic field, and hence it is expected that the heat transfer rate would also increase as the particle velocity increases. Thus, for experimental purposes it is of prime importance that the test object be placed at a velocity anti-node to get the maximum effectiveness out of the process for a given acoustic signal. However, in contrast to the forced convective mean flow case, the current issue with oscillatory flow is considerably more complicated due to the wide range of flow parameters, and hence flow patterns and heat transport mechanisms, that can result.

# II. EXPERIMENT

## A. INTENT

As with any other advance in technology or new scientific discovery with which engineers desire to predict and quantify results in some manner, it is best to begin by first breaking the process down into its basic component parts. By completing an analysis for the simplest version of the model in question, a stepping stone will be established upon which the analysis of more complicated scenarios can be built. It stands to reason that this is how the analysis of the thermoacoustic heat transfer process should also begin.

For an initial starting point, the analogy once again to forced convection heat transfer is used. The problem of an isolated cylinder in a mean cross flow is well documented and understood, and has in turn been used to develop correlations for flow over a collection of cylinders, such as a tube bank, a more practical application as is evident from any basic heat transfer textbook. This is the motivation for a study of the behavior of simple shapes such as a cylinder placed in an acoustic field. It is hoped that with this knowledge for an isolated cylinder, it would be possible to extend the solution to other models.

It is only necessary then to concentrate on the evaluation of the acoustic signal itself in terms of its many different parameters. But before this analysis may begin, the type of acoustic flow around the cylinder must be established. To allow corroboration with established theory, the flow pattern initially desired is that of basic laminar, incompressible flow where well understood streaming patterns are the principal forms of flow and heat transport. This meets the requirement for maintaining the most simplified version of flow for the analysis.

The geometry of how the test cylinder is placed with reference to the acoustic signal is also of utmost importance. A theoretically perfect scenario would have the test cylinder situated normal to a unidirectional sound field with no interference from the surroundings. Such a situation cannot be exactly duplicated, though, due to the nature of acoustic waves to spread and travel in all directions. In order to restrict the acoustic signal to only one direction, it is proposed that the sound field be set up in a cylindrical, resonant sound chamber so that the analysis is properly limited to axial wave modes only.

## B. FUNDAMENTAL IDEAS

Unlike the well known dependence on the Reynolds and Prandtl numbers found in conventional cross flow over bluff bodies, the issue of heat transfer in the presence of an acoustic field is significantly more complicated due to the presence of a multitude of competing length (or time, or velocity) scales. The ways in which these length scales may be ordered are many and lead to numerous distinct parameter regimes with quite drastically different flow properties, and hence heat transfer properties. In order to closely examine the properties of heat transfer in oscillatory flows then, it is first necessary to enumerate some of the different parameters and variables involved. By establishing and maintaining a set of criteria surrounding these parameters, and by modeling the test apparatus to conform to them, the job of evaluating different regimes of flow and drawing correlations from the data obtained will become possible.

This section lists the most important of these parameters and provides reasoning for the choices involved, keeping in mind the desire to maintain the most basic and core set of conditions that flow around the test cylinder be laminar, incompressible and attached, and that only the steady-state solution be considered.

### 1. Criterion A

Following the first assumption that the acoustic streaming flow around the test cylinder be incompressible, two different length scales must be specified. The first of these requires that the relative size of the test cylinder be very small compared to the radian wavelength of the acoustic field, where the radian wavelength is defined as

$$\bar{\lambda} = \frac{\lambda}{2\pi} \tag{1}$$

and the characteristic length scale of the test cylinder is chosen as the radius, $a$. The radian wavelength can be related to the frequency by:

$$\bar{\lambda} = \frac{\lambda}{2\pi} = \frac{c/f}{2\pi} = \frac{c}{\omega} \tag{2}$$

Now, by asserting that $a \ll \bar{\lambda}$, and designating the ratio between the two as $\chi$, it follows that:

$$\frac{a}{\bar{\lambda}} \ll 1 \tag{3}$$

and finally that

$$\chi = \frac{a\omega}{c} \ll 1 \tag{4}$$

The criterion $\chi \ll 1$ ensures that radiation effects due to the acoustic streaming are negligible, as presented by Lighthill (1963) and indicates that it is only the local acoustic field conditions that are of importance.

### 2. Criterion B

The second criterion which is required to support the assumption that flow be incompressible is derived from the relationship between displacement amplitude of particle oscillation in the sound field, $\bar{A}$, and the cylinder radius, $a$. The ratio between the two, $\frac{\bar{A}}{a}$, will be designated as the amplitude parameter, $\epsilon$, and dictates whether or not separation will occur.

When the amplitude parameter is very small,

$$\epsilon = \frac{\bar{A}}{a} \ll 1 \tag{5}$$

the particles in the sound field move a very short distance along the cylinder wall before reversing their direction. This ensures that the flow remains attached, with little chance of separation occurring, and hence the flow will remain laminar at all times. It can also be noted that $\epsilon$ is directly proportional to the pressure ratio $P_0 / P_m$, and can therefore take on much larger values for strong acoustic fields. This is accomplished by observing that the displacement amplitude of a particle in the flow is directly related to its velocity and that the particle velocity is in turn related to the pressure ratio by the following (in a plane standing sound field)

$$\bar{A} = \frac{U_0}{\omega} \tag{6}$$

and

$$U_0 = \frac{cP_0}{\gamma P_m} \tag{7}$$

therefore

$$\epsilon = \frac{c}{a\omega}\left(\frac{P_0}{\gamma P_m}\right) \ll 1 \tag{8}$$

Yet another form of this parameter often used in the literature is called the Keulegan Carpenter number and is defined as $KC=U_0/2af$ and can additionally be expressed as

$$KC = \pi\epsilon \tag{9}$$

Of importance is the fact that the product of the parameters defined in the first two criteria (A and B) is the flow Mach number, which can be defined as

$$M=\chi\epsilon=\frac{U_0}{c} \tag{10}$$

When criteria A and B are satisfied, $M \ll 1$, and this in turn is the second condition which satisfies the assumption of incompressible flow.

### 3. Criterion C

The Stokes boundary layer thickness $\delta$ is related to the kinematic viscosity and the radian frequency of oscillations by

$$\delta = \sqrt{\frac{\nu}{\omega}} \tag{11}$$

and is the well known length scale which is a measure of the extent of viscous effects in an oscillatory flow. A frequency parameter $\Lambda^2$ can be defined as follows

$$\Lambda^2 = \left(\frac{a}{\delta}\right)^2 = \frac{a^2\omega}{\nu} \tag{12}$$

For the case when $\Lambda^2 \gg 1$, the Stokes shear layer is confined to a narrow region and the acoustic streaming effect appears as a slip velocity along the cylinder surface. Utilizing the knowledge that the boundary layer thickness is on the order of $10\delta$ and imposing the condition (somewhat arbitrarily) that

$$\frac{a}{10\delta} > 4 \tag{13}$$

it follows that

$$\Lambda^2 > 1600 \tag{14}$$

is a good criterion to ensure "large" values of the frequency parameter.

The frequency parameter may also be often found in the literature in the form of $\beta = (2a)^2 f/\nu$, and can be expressed as

$$\beta = \left(\frac{2}{\pi}\right)\Lambda^2 \tag{15}$$

### 4. Criterion D

When criteria A - C are satisfied, the acoustic streaming velocity is of magnitude $O(\epsilon U_0)$. A streaming Reynolds number, $R_s$, can then be defined as

$$R_s = \frac{(\epsilon U_0)a}{\nu} \tag{16}$$

Through substitution for $\epsilon$ and $U_0$

$$R_s = \frac{U_0}{a\omega}\frac{U_0 a}{\nu} = \frac{U_0^2}{\omega\nu} = \frac{c^2}{\omega\nu}(\frac{P_0}{\gamma p_m})^2 \tag{17}$$

which yields

$$R_s = \epsilon^2\Lambda^2 \tag{18}$$

This streaming Reynolds number becomes the driving factor in determining what will be the primary mode of heat transport within the region due to the acoustic streaming flow. Stuart (1966) demonstrated that when $R_s \ll 1$, a Stokes flow becomes prevalent in the outer region while a boundary layer flow is predominant when this parameter takes on values much greater than one. In order to ensure that forced convective heat transfer is dominant then, we impose the following constraint

$$R_s \gg 1 \tag{19}$$

### 5. Criterion E

It was first observed by Honji (1981) that flow around a cylinder will become centrifugally unstable and separate into vortices as the amplitude of particle oscillation increases. This instability occurs in the Stokes layer where the flow is parallel to the direction of particle oscillation. This was confirmed by Hall (1984) who conducted a linear stability analysis on the unsteady boundary layer in the high-frequency limit. He found that a critical value of the Reynolds streaming number exists for which instabilities begin to form, namely when $R_s$ becomes greater than $4.24\Lambda$. Recent work in the area by Sarpkaya (1986) provides further explanation for this phenomenon. Since vortex shedding can make a large impact on the heat transport from the cylinder, we will maintain the following criterion, which can be expressed in two different ways as

$$R_s < 4.24\Lambda \tag{20}$$

or, alternately as

$$\epsilon < \frac{2.06}{\sqrt{\Lambda}} \tag{21}$$

An example of what these vortices may look like is shown in Figure 6.

### 6. Criterion F

In order to maintain the condition in which there is minimal influence from the buoyancy effects of natural convection as compared to the forced convective heat transfer due to the acoustic streaming effects, a dimensional analysis of the governing equations produces the following requirement for the Grashof number

$$\frac{Gr}{R_s^2} \ll 1 \tag{22}$$

For the case when $Gr\ /\ R_s^2 \approx 1$ or greater, buoyancy effects must be taken into account and any heat transfer correlations developed will have to be modified accordingly.

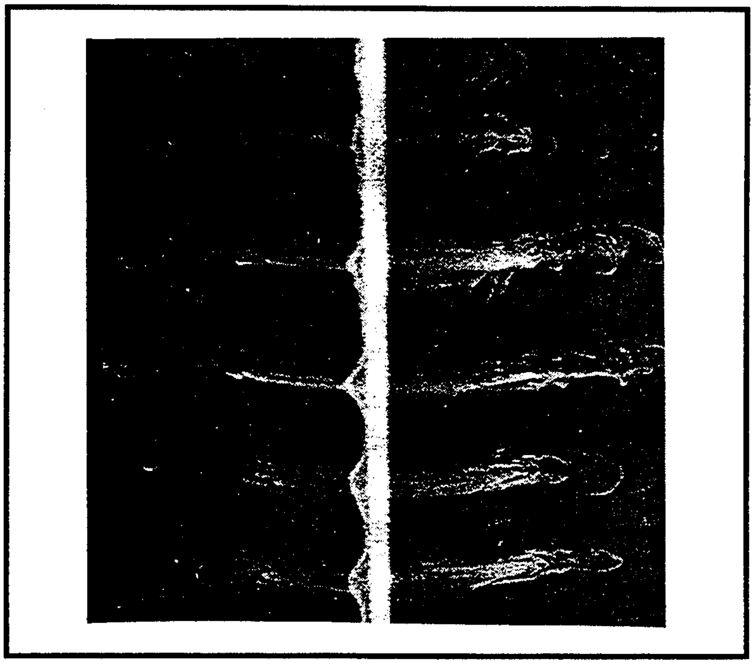

**Figure 6**. Vortices Due to Oscillatory Flow Around a Cylinder. (Sarpkaya, 1986)

### 7. Criterion G

This final criterion stems from the desire to maintain only a plane standing sound field within the test chamber. This means that only the axial wave components excited by the resonant acoustic signal be present, without interference from transverse modes such as the azimuthal modes and radial modes. It may be shown from theory that there is a certain cut-off frequency developed from a solution of the wave equation, below which the transverse modes will not be present. For the cylindrical waveguide geometry being used, the solution for the above condition is obtained in the form of appropriate roots of Bessel functions. If $L$ is the length of the test chamber, the longitudinal frequency can be expressed as

$$f_l = \frac{lc}{2L} \tag{23}$$

where $l$ is the 1st, 2nd, ... , mode number. The transverse frequency mode is expressed by

$$f_{mn} = \alpha'_{mn}\frac{c}{\pi D} \tag{24}$$

where $D$ is the test chamber diameter and $\alpha'_{mn}$ represents the eigenvalues obtained from roots of the Bessel functions. Transverse modes will be present if $f_l = f_{mn}$, so it is desired to maintain $f_l$ well below $f_{mn}$ and $f_l$ now represents the maximum frequency possible while still maintaining this criterion. By substituting for both frequencies, the condition becomes

$$\frac{lc}{2L} < \alpha'_{mn}\frac{c}{\pi D} \tag{25}$$

which is reduced to

$$\frac{l}{2(\frac{L}{D})} < \frac{\alpha'_{mn}}{\pi} \tag{26}$$

By introducing a new parameter called the aspect ratio,

$$Z = \frac{L}{D} \tag{27}$$

and finding the smallest root of this Bessel function,

$$\frac{\alpha'_{mn}}{\pi} min = 0.586 \tag{28}$$

the criterion now becomes

$$\frac{l}{2Z} < 0.586 \tag{29}$$

which can be rearranged to finally get

$$Z = \frac{L}{D} > 0.85\ l_{\max} \tag{30}$$

where

$$l_{\max} = \frac{f_{\max}}{f_{\min}} \tag{31}$$

This gives a relationship between the geometry and the maximum frequency. But since the maximum frequency is already defined using criteria A - F, criterion G in fact gives us the maximum diameter that can be used, or if the diameter is also given, it determines the length of the chamber instead.

### 8. Basic Flow Description

When a cylinder is immersed in a standing acoustic field and all of the previous criteria have been met, particle oscillations will initiate the most basic form of an acoustic streaming flow. This steady flow (Figure 7) is symmetrical about two axis, is circular in nature, and includes a well defined boundary layer. The boundary layer is actually quite small and is greatly exaggerated in the figure for clarity. Although this is not the only flow which is present, it does represent the flow pattern that has the biggest impact as a heat transport mechanism when these criteria are satisfied.

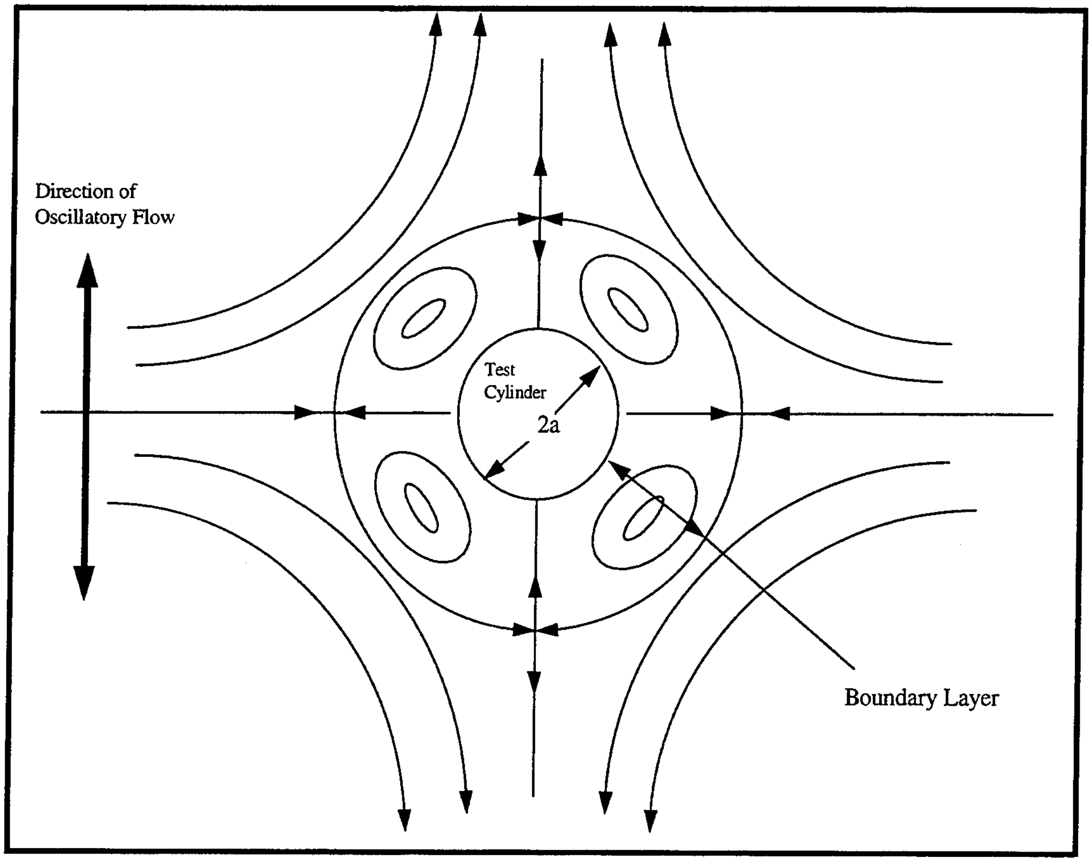

**Figure 7**. Outer Acoustic Streaming Flow (also known as Boundary Layer Flow)

As discussed earlier, this fluid flow regime is the main focus of this investigation in which at first we consider only laminar, unseparated flow around the test cylinder. One of the goals of this experimental study is to determine the range of values for the previously discussed parameters where one flow regime transitions to another and relate them in terms of the streaming Reynolds number. It is believed that such transitions will be reflected in the heat transfer behavior.

In order to define a specific range for laminar flow, though, these criteria needed to refinement by asking the questions; how small is "much less than one" or how big is "much greater than one"? It was determined that Criterion A in Eq. 4 would be met by picking $\chi < 0.1$ and Criterion B in Eq. 5 would be met by choosing $\epsilon < 0.3$. This ensures incompressible flow around the test cylinder and that flow remains attached. Criterion C becomes $\Lambda^2 > 1600$, confining the Stokes shear layer to a narrow region. The above ranges have been fixed based on prior experience and preliminary experimentation, but are not by any means intended to be "hard and fast". They may indeed be modified if necessary. Criteria D and E require verification after each experimental run.

## C. APPARATUS

As previously discussed, the experiment consists of a heated test cylinder placed normal to a simple acoustic standing wave within a resonating sound chamber (Figure 8). This general description can be broken down into three major components; the test cylinder, the sound chamber and the acoustic electronics package, which are further described below.

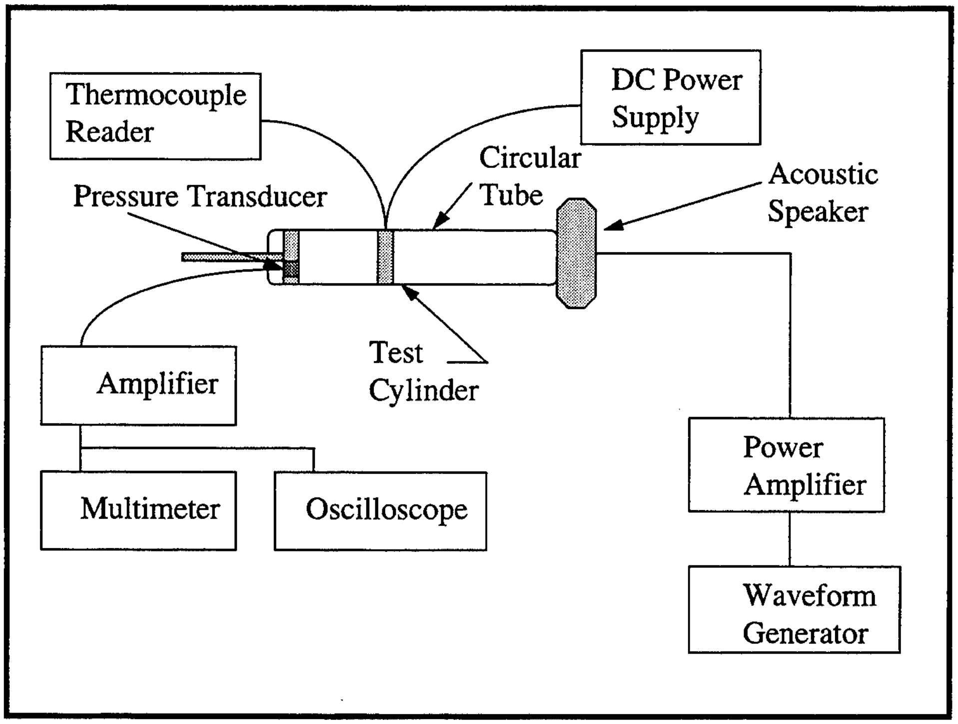

**Figure 8**. Experimental Test Apparatus.

### 1. Test Cylinder

It was originally proposed that a Watlow stainless steel cartridge heater be used as the test cylinder for the experiments. They are available in varying diameters and additionally feature an imbedded type "J" thermocouple placed at the midpoint of its length. This presented problems, however, since the heating along the length of the cartridge heater was uneven and the relatively large thermal resistance of the stainless steel produced large variances in surface temperature along the length. Since constant surface temperature is a feature which is very important to the analysis of heat transfer characteristics, this was unacceptable. Therefore, a copper sheath was designed to fit over the cartridge heater. It was assumed that the large thermal conductivity of copper would even out the axial surface temperature gradient. In addition, silicon oil was liberally applied to the inside of the copper sheath prior to insertion of the cartridge heater before each experimental run (Figure 9). This provides better thermal contact in the narrow annular gap (approximately 2 mm) between the sheath and heater, preventing air gaps which can cause local temperature discontinuities at the surface. This arrangement (as was later verified, Appendix B) provides for an axial temperature variation of less than 0.5°C from one end of the heater to the other for the temperature range of interest in this experiment. A picture of the test cylinder is shown in Figure 10.

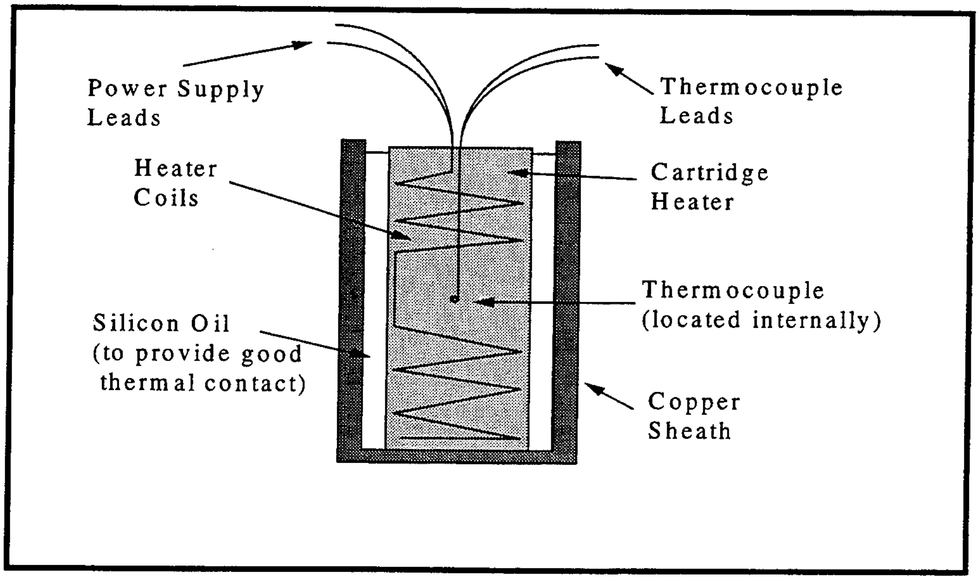

**Figure 9**. Test Cylinder Assembly.

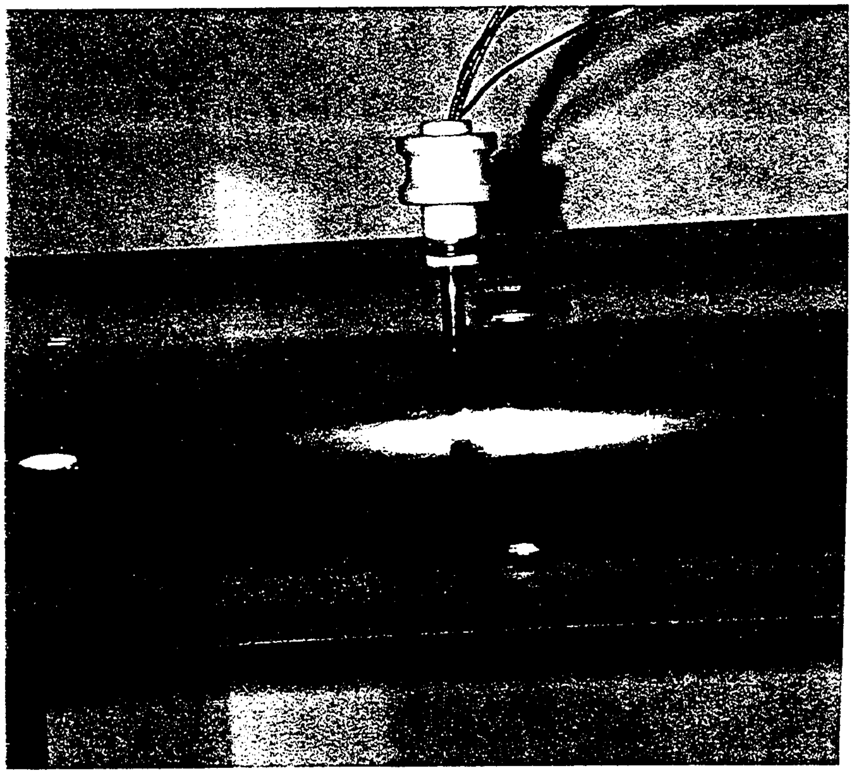

**Figure 10**. Photo of Test Cylinder inserted into the Sound Chamber.

As was stated earlier, the surface temperature of the test cylinder is a required datum point for the analysis. Since the only provision for temperature measurement is at the thermocouple placed at the center of the test cylinder, the equivalent resistance of the steel/oil/copper circuit is required in order to deduce the surface temperature from the cartridge heater center temperature as measured by the imbedded thermocouple. Appendix B gives a detailed analysis of the derivation of the resistance, which is approximately 1.019 K/W.

The cartridge heater receives its power from a Kikusui Model PAR 160A regulated DC power supply. It provides power control measurement down to 0.01 amps and 0.01 volts. Thermocouple measurements are provided by a Keithley Model 740 scanning thermometer system. Calibration data for all thermocouples and the thermocouple reader is provided in Appendix B.

### 2. Sound Chamber

The purpose of the sound chamber is to provide an environment through which acoustic signals of various frequencies can be used to excite a resonant standing wave. In order to accomplish this for all frequencies which may be used during the experiment, a resonant chamber that would be adjustable in length was highly desired. Figure 11 shows the final configuration of the test chamber while Figure 12 shows a photo of the test apparatus.

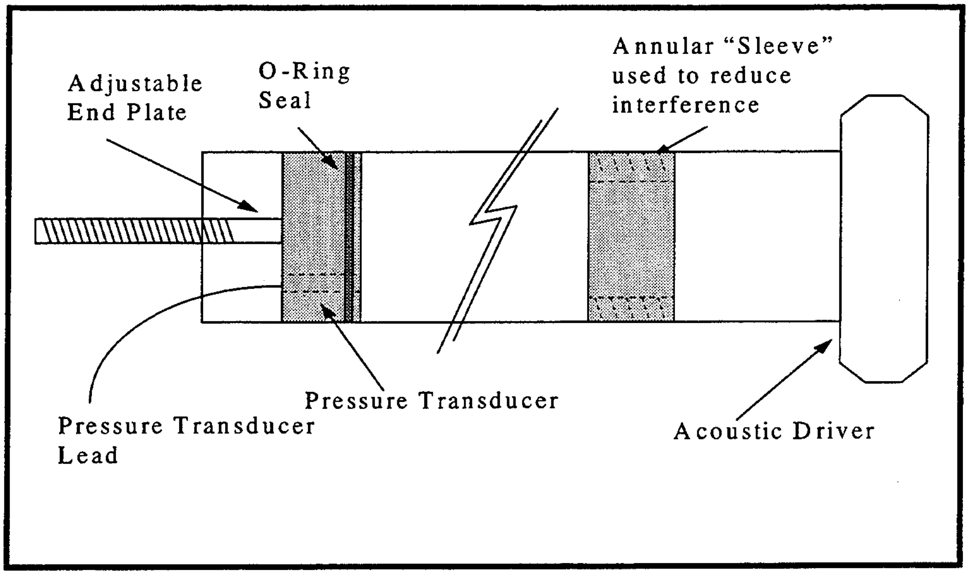

**Figure 11**. Sound Chamber Assembly.

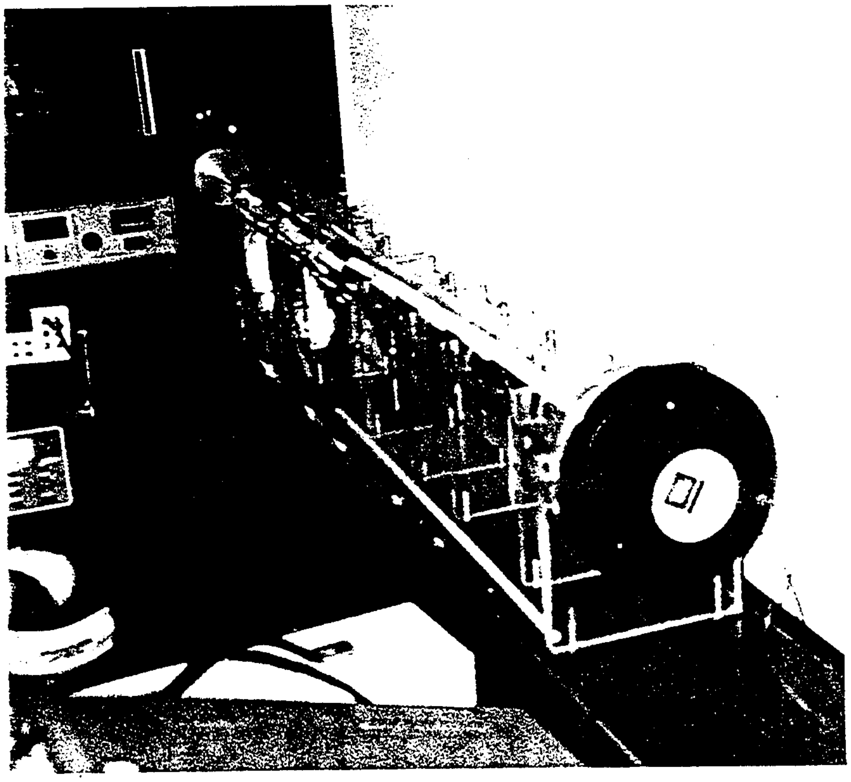

**Figure 12**. Photo of Test Apparatus. Acoustic Driver is on to the right.

The test chamber itself is a plexiglass tube approximately two meters long which is mounted firmly to a plexiglass base plate. The acoustic driver is mounted at one end and provides the source of the acoustic signal. The opposite end has a movable flat end plate which has an o-ring seal to help isolate the acoustic wave in the chamber. The end plate serves as the rigid end termination while the o-ring provides good sound confinement, as well as good stability for the end face so that it doesn't become offset to either side as its position is varied along the length of the enclosing resonant chamber.

A hole through this end plate provides access for a pressure transducer which is used to help deduce the pressure ratio, and hence the sound pressure level for that configuration of frequency and input power. The pressure transducer used is an Endevco model 8510B-5 which has an output in millivolts and has a pressure sensitivity of 50.89 mV/psi. This is connected to a preamplifier with a gain of 100 and provides output to both an oscilloscope and a Hewlett-Packard model 34401A multimeter. Measurement of the voltage output from the multimeter is important to determine when resonance has occurred within the chamber for as the frequency is varied, the output voltage from the microphone decreases on either side of the resonant operating point.

The oscilloscope provides a visual representation of the time trace of the acoustic signal at the end of the sound chamber, corresponding to a pressure antinode, and is used to ensure that the signal remains sinusoidal throughout the experimental range of powers and frequencies. During the initial stages of the experiment, the oscilloscope allowed for the discovery of interference patterns in the sinusoidal waveform as caused by higher order harmonics at high SPLs (> 155 dB). In order to limit the interference that was present, the use of "sleeves" within the chamber was recommended to detune the resonant mechanism. This would prevent the harmonics from being integral multiples of each other and thereby prevent them from reinforcing each other to form interference patterns. By placing a sleeve at an appropriate spot in the chamber, some of the high frequency harmonics leading to interference could be eliminated, allowing for even higher SPLs to be achieved before interference occurred.

### 3. Acoustic Electronics Package

Of great importance to the experiment is the ability to generate a nearly pure sinusoidal waveform at varying frequencies and high power ranges. As the strength of the signal generated increases, the effect of the flow around the test cylinder becomes more pronounced, enhancing the heat transfer characteristics of the system.

The acoustic signal being generated at the driver end of the sound chamber is provided by a Hewlett-Packard model 33120A arbitrary waveform generator. It sends a sinusoidal waveform at the proper frequency through a Techron model 7540 power supply amplifier to a JBL model 2490H acoustic compression driver.

A more detailed review of each item of equipment used in the system is provided in Appendix D.

## D. EXPERIMENTAL METHOD

Prior to gathering data for this experiment, it was first necessary to develop a coherent plan with which to approach the problem. The first step required was to find specific frequencies at which resonance occurred within the chamber, and which would also provide a velocity anti-node at the position of the test cylinder. By looking at the geometry of the problem (Figure 13), it became obvious that these limiting factors could be met by a combination of adjusting the end plate distance from the test cylinder, as well as the signal frequency, so that the length L from the heated cylinder to the end plate termination was an odd multiple of $\lambda/4$. This could be further refined to state that the value of 4Lf/c needs to be an odd integer. When this condition was satisfied, the requirement of a velocity anti-node occurring at the cylinder location was met.

The next thing needed was an estimate of the maximum pressure ratio, and therefore the sound pressure level that could be obtained. This was achieved by increasing the amplitude of the input signal waveform until the output waveform on the oscilloscope began showing traces of interference or other disturbances. When the maximum input amplitude was obtained, the multimeter output was recorded.

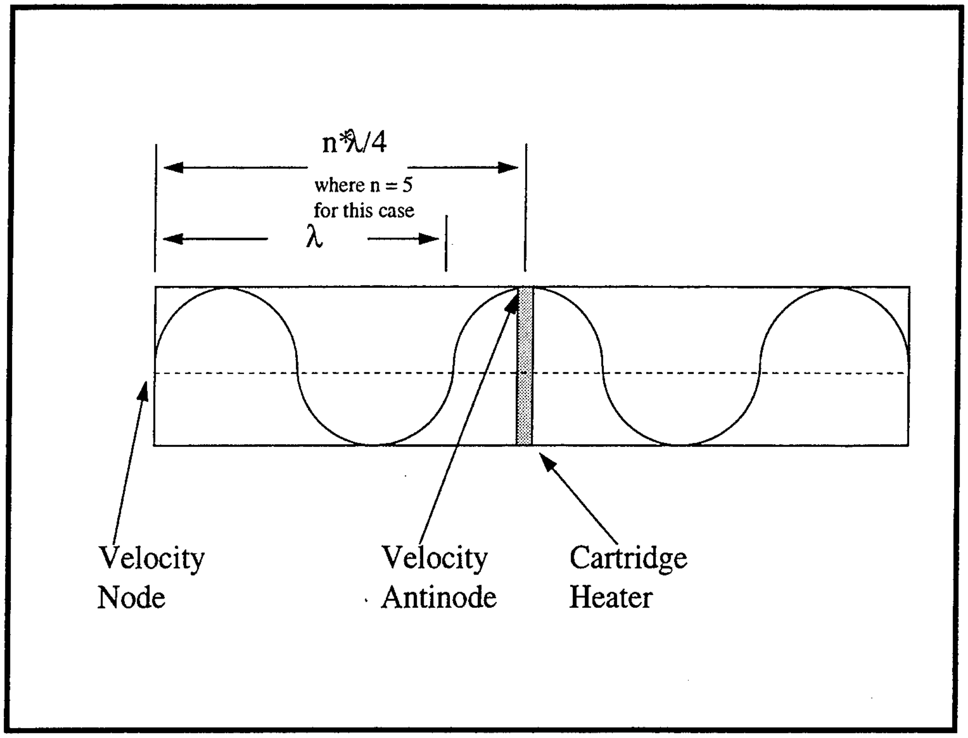

**Figure 13**. Proper Geometry so that Maximum Velocity occurs at the Test Cylinder.

In order to convert the output voltage to an actual pressure ratio and sound pressure level, it was necessary to first understand what form the multimeter uses to present the output. The multimeter gives the voltage output in terms of the true RMS value of the sinusoidal signal, or rather $V_0/\sqrt{2}$, where Vo represents the voltage amplitude from zero to peak of the sinusoidal signal. Recall that the true RMS value for the pressure can also be expressed as $P_0/\sqrt{2}$. Then, the following relationship holds true, that

$$P_0/\sqrt{2} = \frac{V_0/\sqrt{2}}{S} \tag{32}$$

where S is the sensitivity of the pressure transducer in mV/Pa.

The sensitivity of the pressure transducer after passing through the 100 gain setting of the preamplifier was converted and expressed as 0.74 mV/Pa. By substituting into the above equation, the pressure amplitude becomes

$$P_0 = \frac{V_0/\sqrt{2}}{0.523mV/Pa} \tag{33}$$

where it is noted again that $V_0 \ / \ \sqrt{2}$ is the multimeter output.

From this, a pressure ratio can be defined as

$$PR = \frac{P_0}{P_m} \tag{34}$$

where $P_m$ is the mean ambient pressure of 101 kPa. The pressure ratio is typically expressed in terms of a percentage.

The sound pressure level is defined as the logarithmically scaled ratio of the RMS pressure and a predetermined reference pressure, $P_{ref}$, where $P_{ref}$ is chosen to be 20 μPa for gases (by convention). This gives

$$SPL = 20 \log_{10} \frac{P_0/\sqrt{2}}{P_{ref}} \tag{35}$$

In order to obtain an idea of how strong the acoustic signal is during the experiments, Table 1 gives the sound pressure level for various activities

| Activity | Sound Pressure Level (dB) | Pressure Ratio (%) |
|---|---|---|
| Normal Conversation | 60 | < 0.001 |
| Jet Airplane at Take-off | 90 | < 0.01 |
| Pain Threshold | 120 | 0.28 |
| Minimum Experimental Level | 150.6 | 0.94 |
| Maximum Experimental Level | 161.2 | 3.20 |

Table 1. Samples of SPL and PR for Comparison.

After finding the pressure ratio, and therefore the SPL, the actual data extraction phase of the experiment could be initiated. It was preceded by with an understanding of what type of data was needed for analysis. A crucial element of this experiment is the need to obtain a broad base of data with which to incorporate the results. In order to obtain this, experiments were run at several different pressure ratios for each resonant frequency found, starting from as low as 0.9% and building up to the maximum pressure ratio by increments of 0.1%. In order to obtain a spread of data points at each pressure ratio evaluated, the test cylinder was heated to approximately 8, 12 and 16 degrees above the ambient temperature. This kept the power requirements low and reduced the amount of thermal input into the ambient air within the sound chamber. This latter point was necessary as the ambient temperature could rise as much as 0.3 degrees during a single experimental trial. In order to ensure reproducibility and reduce the effect of anomalistic behavior, three runs at each temperature point were conducted to ensure consistency of data. The selected temperatures were only guidelines and were not meant to be hard set points for the experiment. Instead, they were treated as aim points with an acceptable range of ± 1 degree. Therefore, in order to produce an even broader spread of data, the power input to the test cylinder was varied slightly for each of the three trials at each specific temperature point.

Once the selected frequencies and pressure ratios had been determined and a suitable starting pressure ratio and temperature had been obtained, the experimental process was initiated. In order to obtain the selected pressure ratio for a particular set of runs, it was necessary to get an idea of the settings required for each specific piece of equipment. This was done by selecting the appropriate frequency on the waveform generator and modifying the power amplification on both the waveform generator and the power amplifier until the appropriate pressure ratio was obtained from the multimeter. The frequency was then adjusted to fine tune the resonance. A check of the oscilloscope at this point ensured that the signal being generated was of the right waveform and that interference was not occurring. Then the power amplifier to the acoustic driver was turned down to zero after noting the level at which it was set. This allowed for obtaining the correct pressure ratio in a quick manner by simply turning the power amplifier up to the previously noted value.

It was necessary at this point to ensure that the test cylinder was properly prepared. This entailed introducing approximately ten drops of silicon oil into the copper sheath and inserting the cartridge heater. The cartridge heater would be completely immersed in the silicon oil after being fully inserted. After a period of time, there would be some loss of silicon oil due to the wick action of the thermocouple and power leads emerging from the top. This was insignificant during the runs required for a single pressure ratio and caused a negligible change in the center-to-surface resistance as noted in Appendix B, but it became good practice to add some of drops of oil each time a new set of runs at a different pressure ratio were to be taken.

The test cylinder was then inserted into the sound chamber, making sure that the bottom of the cylinder was resting in a shallow indentation specifically machined into the inside face of the chamber. Power to the cartridge heater was then turned on and set so that a steady state temperature of approximately eight degrees above ambient would occur when the acoustic signal was present. This became more of an art form and required familiarity with the system to accomplish it with any degree of accuracy.

Since the power to the acoustic driver at this point was still at zero, the power to the cartridge heater would drive the temperature of the test cylinder past the projected steady state temperature. As it approached the projected temperature, though, the power to the acoustic driver was increased to the previously noted set point. This provided the fluid flow at the predetermined pressure ratio, in effect beginning to cool the test cylinder until it reached a steady state condition. At this point, the rate of energy input to the cylinder was equal to the rate of energy being convected away from the cylinder. By monitoring the interior thermocouple temperature, it was easy to see when the lowest temperature was reached. When the temperature began to rise once again, it was determined that the steady state condition had been reached and that the resultant temperature rise being witnessed was due only to the test cylinder transferring heat into the surrounding fluid medium, thus raising the overall ambient temperature.

Two situations other than the ideal one presented above occurred frequently due to the coarse means of trying to arrive at the desired cylinder temperature. If upon engaging the power to the acoustic driver the temperature of the test cylinder did not decrease but continued to increase at a slower rate instead, then the power being supplied to the cartridge heater was deemed too high and the voltage reduced until a decrease in temperature was witnessed. If upon engaging power to the acoustic driver the temperature of the test cylinder were to continue decreasing lower than the desired temperature range, it was an easy matter to increase the voltage to the cartridge heater to increase the steady state temperature solution.

When the steady state solution point was reached, the frequency and microphone voltage were noted, as was the voltage and current supplied to the cartridge heater and the temperature of the thermocouple in the cartridge heater. The power to the heater and the power to the acoustic driver were then simultaneously turned off and the test cylinder was quickly removed from the sound chamber. A second thermocouple was then introduced through the access hole in the sound chamber (from which the test cylinder had just been removed) such that the location of the thermocouple was approximately at the center (i.e., along the axis) of the sound chamber. This thermocouple temperature was then monitored until it "plateaued" and provided the measurement of the ambient temperature within the sound chamber.

This completed a single experimental trial for a specified resonant frequency, pressure ratio and temperature. The procedure was carried out a total of nine times for each different pressure ratio. Once the six outputs for each run were recorded, they were then transferred over to a spreadsheet where all other significant parameters were computed automatically. The following section delineates the various calculations performed in the spreadsheet.

## E. EXPERIMENTAL CALCULATIONS

The first calculation desired from the spreadsheet entails finding the actual power being supplied to the cartridge heater. This is expressed in terms of the current and voltage outputs from each experimental run.

$$P = IV \tag{36}$$

Once the power to the cartridge heater was known, the surface temperature of the test cylinder itself could be calculated. Knowing the resistance of the thermal circuit as given in Appendix B, the difference between the interior temperature and the surface temperature is simply

$$\Delta T = PR_{eq} \tag{37}$$

Utilizing the interior temperature output as provided by the thermocouple embedded in the cartridge heater, the surface temperature of the cylinder is then expressed as

$$T_s = T_c - PR_{eq} \tag{38}$$

Once the surface temperature is known, the difference between it and the ambient temperature, as measured during the experiment, is calculated. The result is then combined with the power calculated in Eq. 35, as well as with the external surface area of the test cylinder, to find the convective heat transfer coefficient

$$h = \frac{P}{A(T_s - T_a)} \tag{39}$$

The Nusselt number is then derived from the following equation

$$Nu = \frac{hd}{k} \tag{40}$$

where d is the test cylinder diameter and k is the thermal conductivity of air.

The next step is to calculate the various criteria as previously listed in the theory section. In order to find the length scale ratio, $\chi$, the speed of sound within the chamber must first be calculated using the ambient temperature

$$c = \sqrt{\gamma R(T_a + 273.15)} \tag{41}$$

The value of $\chi$ can now be found from Eqs. 1 - 4. The amplitude parameter, $\epsilon$, is derived in the spreadsheet by combining the pressure ratio from Eq. 33 along with Eq. 8. The third parameter calculated is the frequency parameter, $\Lambda^2$, from Eqs. 10 and 11.

The streaming Reynolds number, $R_s$, is found by using Eq. 16. This, however, does not represent the true value at the test cylinder position due to its not being precisely at the velocity antinode. A corrected value for $R_s$ can be deduced by finding the particle velocity offset between the velocity antinode location and the test cylinder position. This offset is derived by knowing the frequency of the sinusoidal signal being generated, the speed of sound within the chamber from Eq. 40, and the distance from the test cylinder to the end plate termination face, L. Hence

$$U_{0_{corrected}} = U_0 |\sin( \frac{4L}{c/f} \frac{\pi}{2} )| \tag{42}$$

or

$$U_{0_{corrected}} = U_0 | \sin ( \frac{2\pi L}{\lambda} ) | \tag{43}$$

Since $R_s$ is proportional to $U_0^2$, it then follows that

$$R_{s_{corrected}} = R_s |\sin(\frac{2\pi L}{\lambda})|^2 \tag{44}$$

from which it was found that the corrected value for $R_s$ had less than a 0.1% error due to the slightly displaced location of the cylinder.

# IV. RESULTS AND DISCUSSION

Nearly 600 experimental trials were performed throughout the course of this study which produced results for 183 distinct data points. Data were obtained for five different frequencies at various pressure ratios ranging from 0.9 % to 3.2 %. Three separate series of trials were performed at each acoustic signal setting, (i.e., at each frequency and pressure ratio setting) corresponding to three separate settings for the driving temperature difference between the test cylinder surface and ambient conditions. The resultant values of the streaming Reynolds number ranged from 40 to 1070 while the corresponding Nusselt numbers obtained varied from 8 to 38. Figure 14 is a parameter map as suggested by Richardson (1967) which shows the range of values for the experimental data covered plotted as a function of the amplitude parameter versus the frequency parameter, and delineates the expected different regimes of flow. The data obtained cover a very narrow regime of this parameter map as was intentionally planned for this experiment. Now it can be seen that the heat transfer results obtained through experimentation are quite evenly distributed between two distinct regions on the map. Region A represents the regime in which the flow is expected to remain laminar, incompressible and attached, and outer acoustic streaming is the main heat transport mechanism. This region is well understood in theory but has yet to be thoroughly verified through experimentation. It is anticipated that the heat transport mechanism for the data in region B will be presented as a combination of effects, including that of vortex shedding, as predicted by Honji (1981), Hall (1984) and Sarpkaya (1986).

The heat transfer results are presented as plots of Nu vs. $R_s$ (Figure 15). Here the difference between the two regions of varying heat transport mechanisms becomes more apparent. A break clearly occurs in the region where $R_s \sim 240$ (± 20) and it can be concluded that there is some critical point in this range where there is a transition in the flow at which vortex shedding begins to become a dominant factor in the heat transport away from the test cylinder. In order to better examine the differences between these two regimes, the data is divided into their respective groups and individually analyzed.

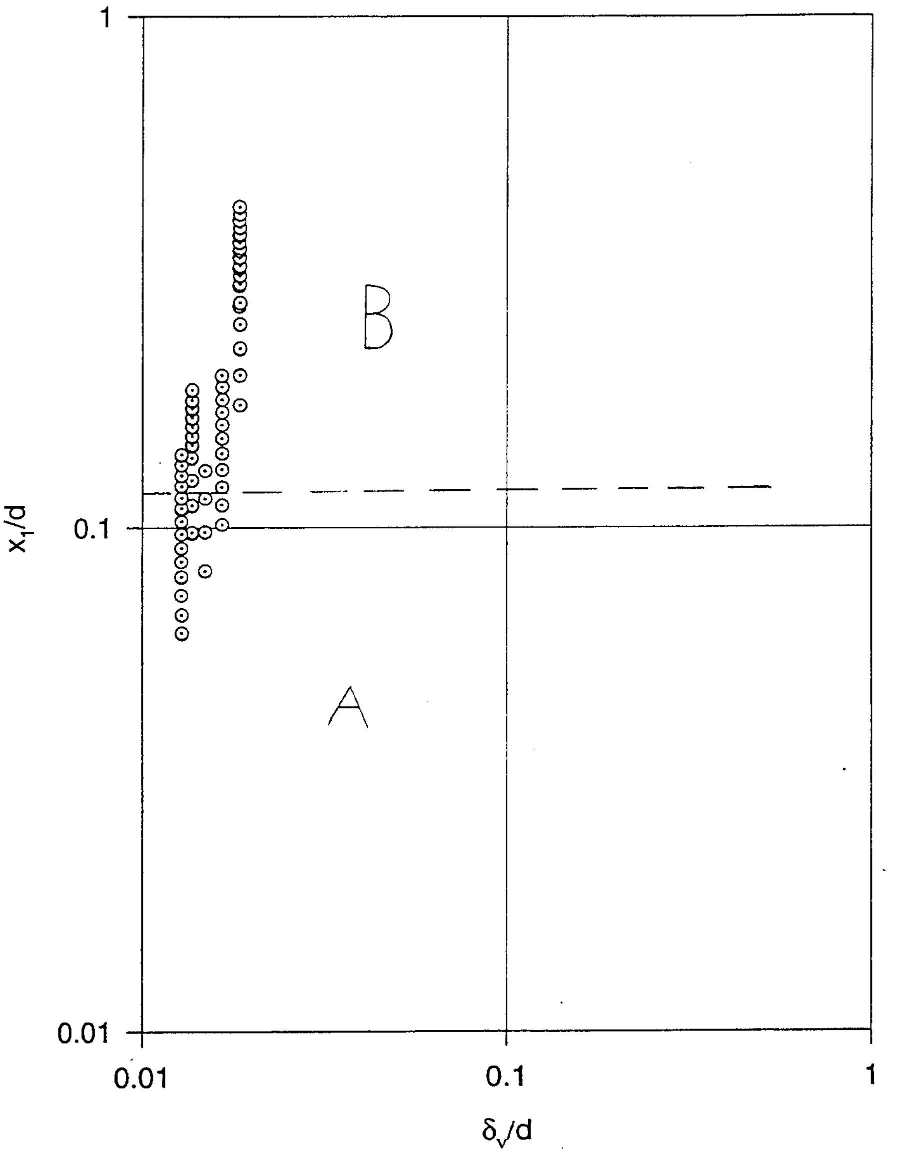

**Figure 14**. Parameter Map of Expected Heat Transfer Regimes as presented by Richardson (1963): Convection by Inner Acoustic Streaming (A), by Outer Acoustic Streaming (B).

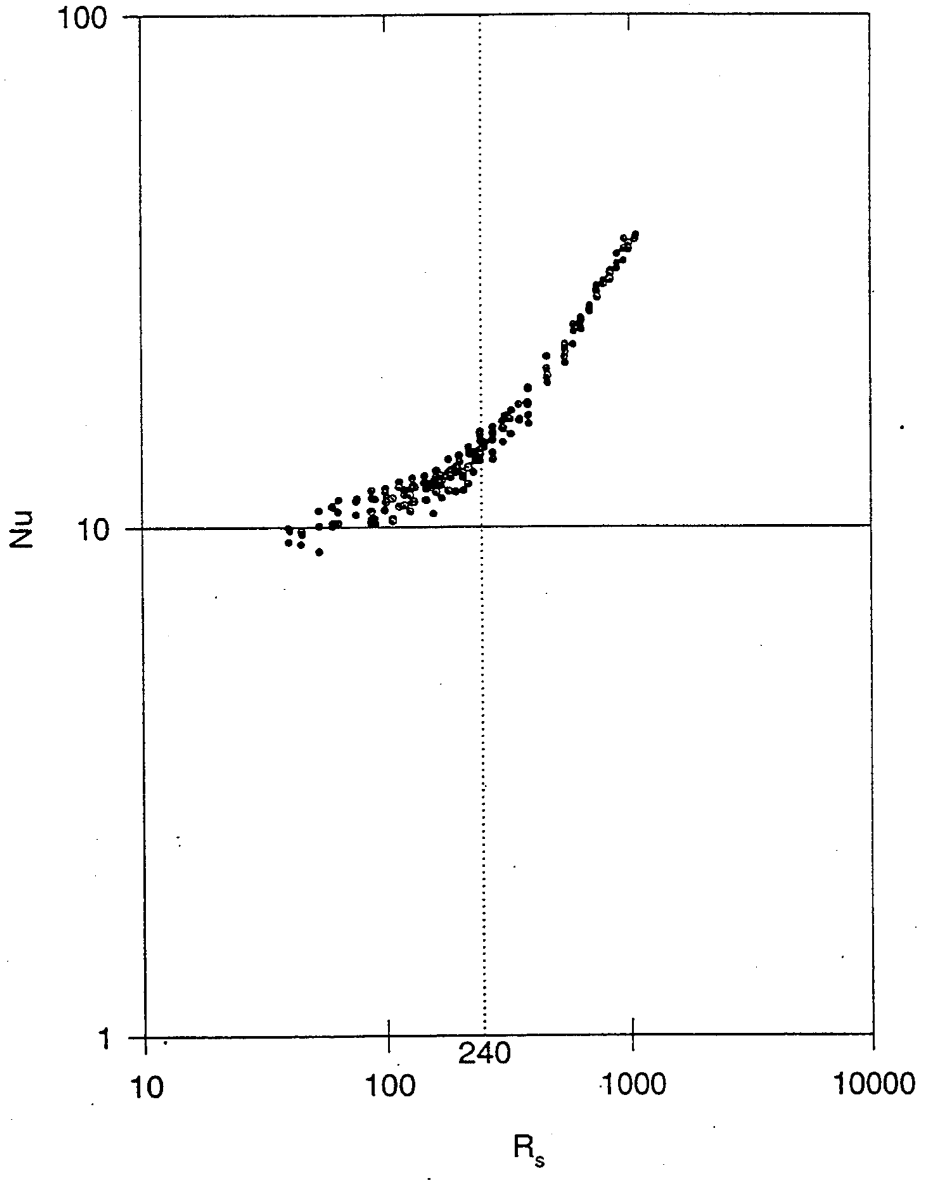

**Figure 15**. All Data Plotted as a Function of Nusselt Number vs. Streaming Reynolds Number.

## A. LAMINAR, ATTACHED FLOW REGIME

Figure 16 is a plot of the heat transfer results in terms of the Nusselt number versus the streaming Reynolds number for the data in which $R_s < 240$, and for which criteria A through C (Eqs. 4, 5, 15) have been met. Those data points which do not meet these criteria have been disregarded. The critical parameters for the remaining data are as follows:

- $\chi < 0.1$
- $\epsilon < 0.3$
- $\Lambda^2 > 1800$
- $\dfrac{R_s}{\Lambda} < 4.5$

Theory clearly indicates that the dependency of the Nusselt number on the streaming Reynolds number in this regime is of the form $Nu = xPr^yR_s^{0.5}$. Since the Prandtl number remains constant throughout the experiment, the solution for this dependency be can further simplified as $Nu = CR_s^{0.5}$, where the term "C" encompasses both the Prandtl number and the qualitative constant of the previous equation. However, this solution form is only valid for "large" values of $R_s$. Since the theory does not provide a definite limit for what qualifies as "large", this criterion had to be determined from a careful examination of the experimental data. From Figure 16, it can be observed that there is indeed a break point at $R_s \sim 130$ where the results diverge into two separate solutions. It was found that the square-root dependency on $R_s$ does not significantly change past this value, and it is therefore suggested that this may be in the range of the lower limit of "large" values of $R_s$. For those values in which $R_s > 130$, a curve fit of the heat transfer characteristics results in a solution of the form

$$Nu = 0.94R_s^{0.5} \tag{45}$$

and it can therefore be determined that the range of values $130 < R_s < 240$ is representative of "large" values of the streaming Reynolds number. The values below $R_s = 130$ are excluded as not being large enough due to a variety of reasons as described later.

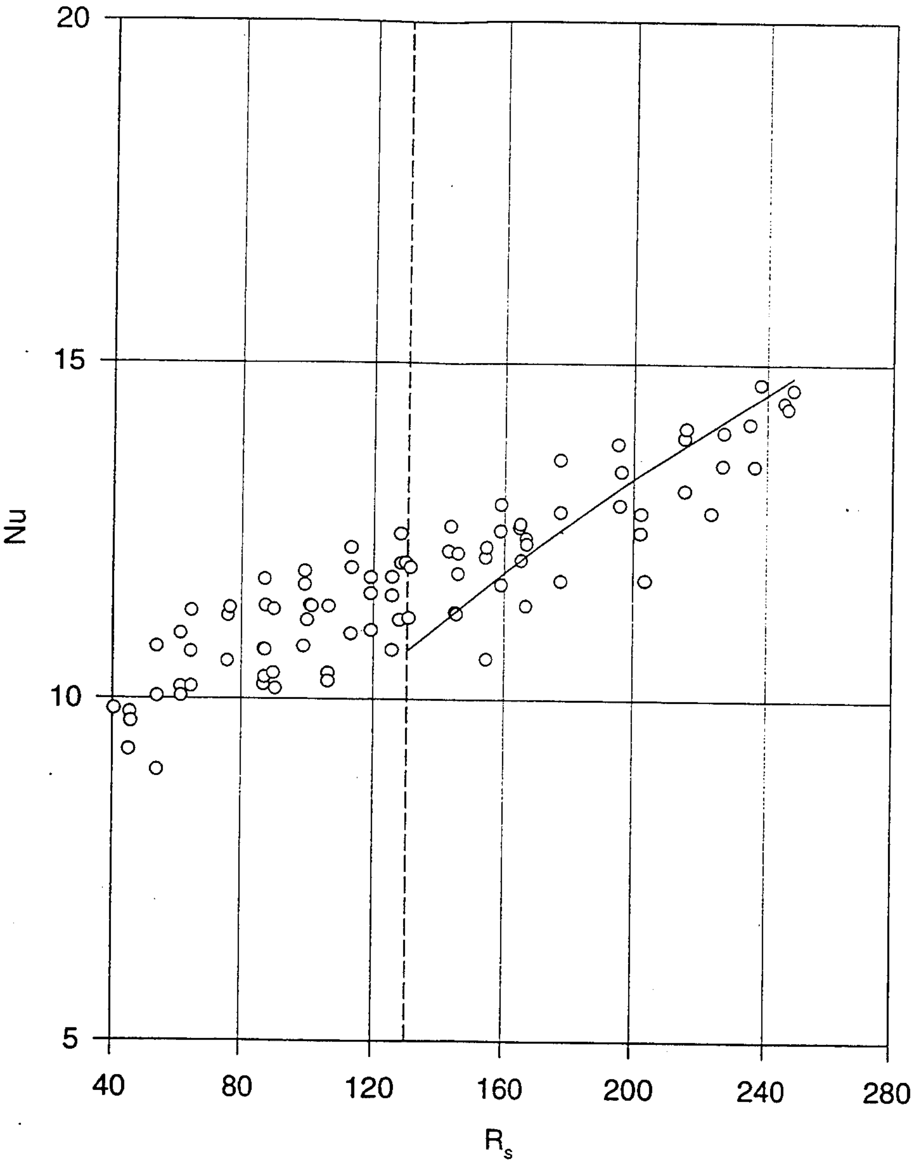

**Figure 16**. Laminar, Attached Flow Regime for $R_s < 240$ (Curve Fit Shown).

Davidson (1973), in an extension of the work by Richardson, analytically and numerically tackled the problem of heat transfer from a cylinder in a strong acoustic field in great detail. He obtained a correlation of the dependency of the Nusselt number on both the Prandtl and streaming Reynolds numbers. The correlation, as extracted from the work of Davidson by Gopinath and Mills (1993) for this regime, is of the form

$$Nu = 1.388 Pr^{0.73} R_s^{0.5} \tag{46}$$

By taking Pr = 0.7 for air for these experiments, the equation then becomes

$$Nu = 1.07 R_s^{0.5} \tag{47}$$

The experimental fit in Eq. 45 under predicts by about 13%, but supports this correlation well within the limits of uncertainty.

Figure 17 is a plot of the region in which Eq. 45 is valid, and includes the experimental uncertainty of each data point as derived in Appendix C. It can be observed from this plot that the deviation from the curve fit in this range of values for $R_s$ is well within experimental uncertainty limits.

Although the lower end of the range for "large" $R_s$ in which the predicted solution is valid has been determined to be 130 for the results obtained from these experiments, it is by no means an absolute boundary. Even though the resultant heat transport characteristics deviate significantly below that point in the region where "intermediate" values of $R_s$ are present, there are several factors which could account for part of the discrepancy, especially in the region around $100 < R_s < 130$. These include uncertainty due to equipment limitations and the effects of natural convection and conduction of heat away from the test cylinder.

The effect of natural convection on most of the intermediate values of $R_s$ is negligible, though, as characterized by the very low ratio of the Grashof number to the square of the streaming Reynolds number (except at very low values of $R_s$). The effect due to conduction is much harder to quantify in so simple a form, though. Conduction can and does occur during the experiment at two separate places where the test cylinder is in contact with

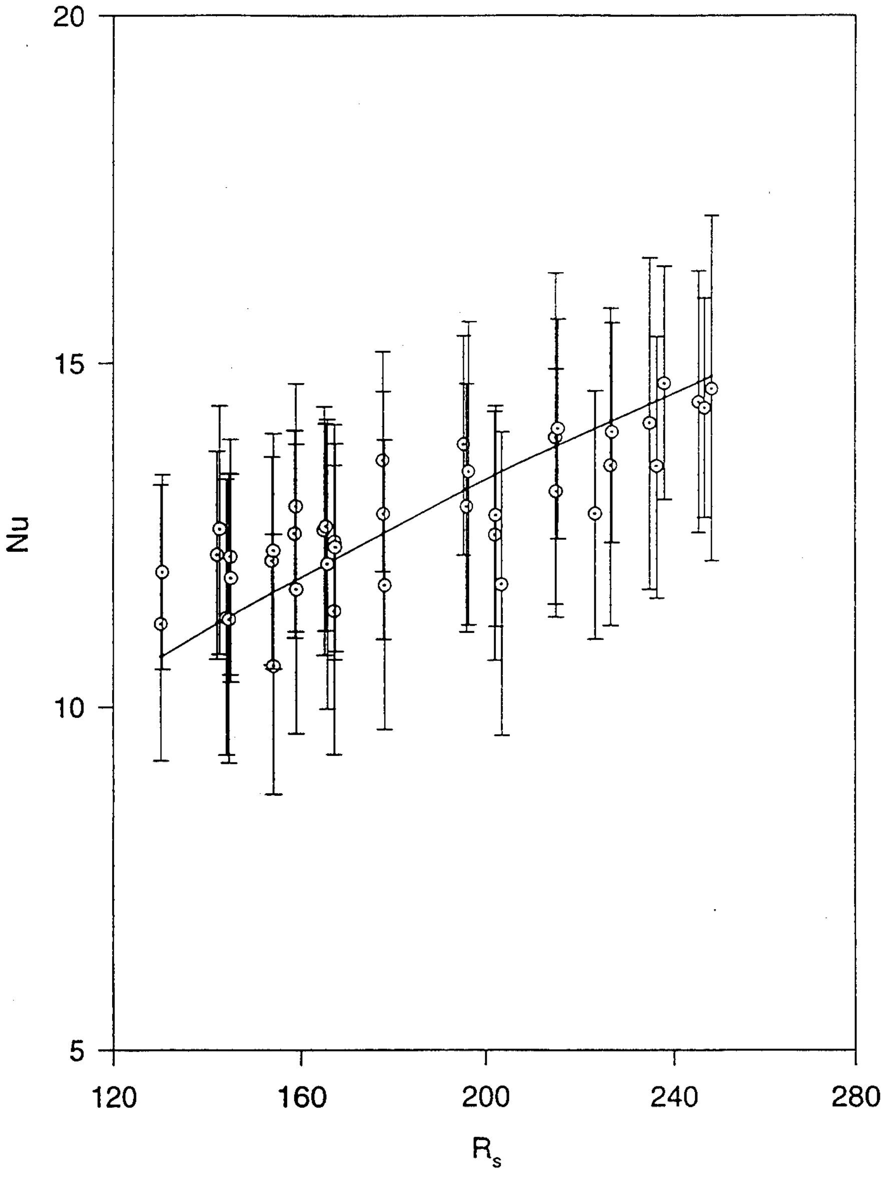

**Figure 17**. Laminar, Attached Regime for Large $R_s$ with Uncertainty Bars.

other apparatus. The top of the test cylinder is in contact with the "plug" used to hold it in place, while the bottom of the test cylinder is allowed to rest in a small depression on the wall of the plexiglass sound chamber. Realizing, though, that the contact area at both points is very small, and that the thermal resistance of the plug and the plexiglass wall are both relatively high (due to their low thermal conductivity), the heat transport away from the test cylinder can be assumed to be negligible as well.

The uncertainty in the results due to the equipment limitations, though, does have a very significant impact on the results. The calculated value of the Nusselt number has an uncertainty of up to 20% ( see Appendix C) depending upon the power being dissipated by the test cylinder. Since the experiment revolves around finding the heat transfer characteristics at specific values of temperature difference between the test cylinder surface and the ambient conditions, correspondingly low power dissipation from the cylinder occurs as the streaming Reynolds number decreases. Therefore, the region of intermediate values of $R_s$ have relatively low electrical heat dissipation, and hence low current values associated with them, dropping to as low as 0.06 amps in some cases. Since the equipment uncertainty for the current reading is of the order of the last digit present, this particular component of the Nusselt number has an uncertainty of nearly 18% by itself and greatly influences the overall uncertainty. Therefore, it may be more accurate to define the lower limit of large $R_s$ values as somewhere between 100 and 130. However, the error due to equipment measurements is not enough to compensate for the disparity between theory and experiment at values much less than 100.

## B. SEPARATED FLOW REGIME

The second regime which this experiment encompasses is that in which vortex shedding and other forms of unsteady flow begin to affect the heat transport characteristics. Figure 18 is a plot of the resultant data in this regime as obtained during experimentation in terms of the Nusselt number versus the streaming Reynolds number. A curve fit of the data results in a solution of the form

$$\mathrm{Nu} = 0.31 R_s^{0.69} \qquad (48)$$

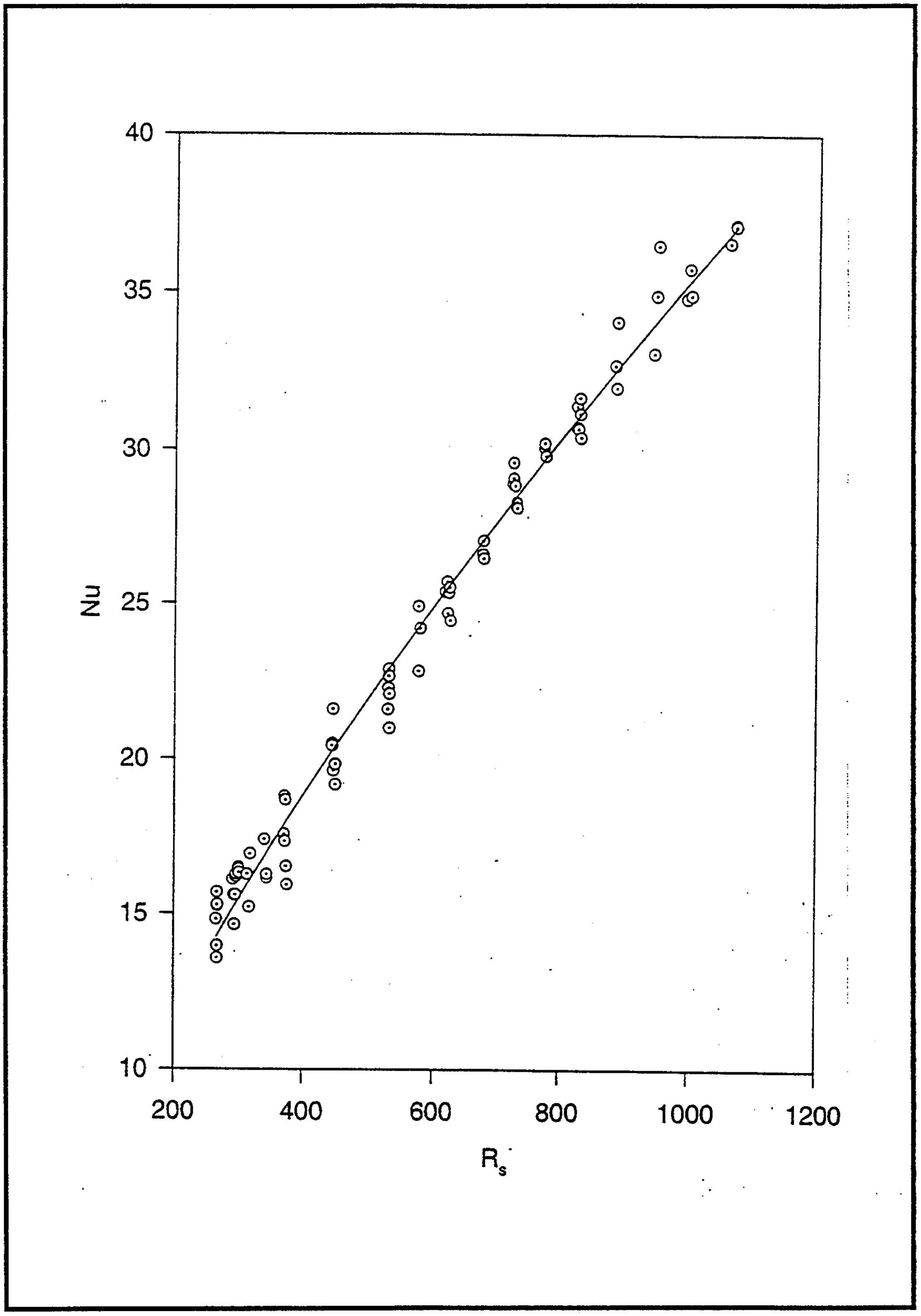

**Figure 18**. Unstable Regime.

There is no theory for this flow regime with which to compare the results, but it is reasonable to assume that this curve fit is representative of the correct solution. As expected, the unstable flow resulting at higher values of $R_s$ would increase the heat transfer rate from the cylinder, and hence the stronger dependency that the Nusselt number has on the streaming Reynolds number, as opposed to the usual square root dependence.

# V. CONCLUSIONS

Experiments were conducted to observe the convective heat transfer rates to an isolated cylinder in an acoustic standing wave. A comparison of the various length scales and other parameters was conducted, and the experimental method stated. During the experiment, the properties of the acoustic field were varied to provide a large base of data which was then analyzed and discussed. Several regimes of interest were investigated and the results presented. Figure 19 is a plot of all data obtained with curve fits for the regimes of interest.

Essentially, heat transfer from a cylinder in a zero-mean oscillatory flow as represented by an acoustic standing wave can be divided into at four separate regimes in which different heat transport mechanisms dominate. For very low values of the streaming Reynolds number, $R_s$, convective effects due to the acoustic field are negligible and natural convection is then the dominant mode of heat transport. For intermediate values of $R_s$, there is a stronger dependence on $R_s$ but not yet on the order of $R_s^{0.5}$ since $R_s$ is still not large enough for flow to be of the boundary layer type. Buoyancy effects are comparable in the lower end of this regime, becoming small for larger values of $R_s$. For much larger values of $R_s$, past 100 or so, an acoustic streaming flow presents itself in the boundary layer, resulting in a square-root dependency on $R_s$. Experimentally, the results obtained in this regime closely match the expected theory, and the heat transfer characteristics may be estimated by Eq. 45. Finally, past a critical value of $R_s \sim 240$ (which confirms well with theory), an unstable flow with vortex shedding begins to take place at the surface of the cylinder, increasing the dependency on $R_s$ which the overall heat transfer solution has. The heat transfer characteristics in this regime may be estimated from Eq. 48. It is these last two of the above regimes that formed the focus of this study.

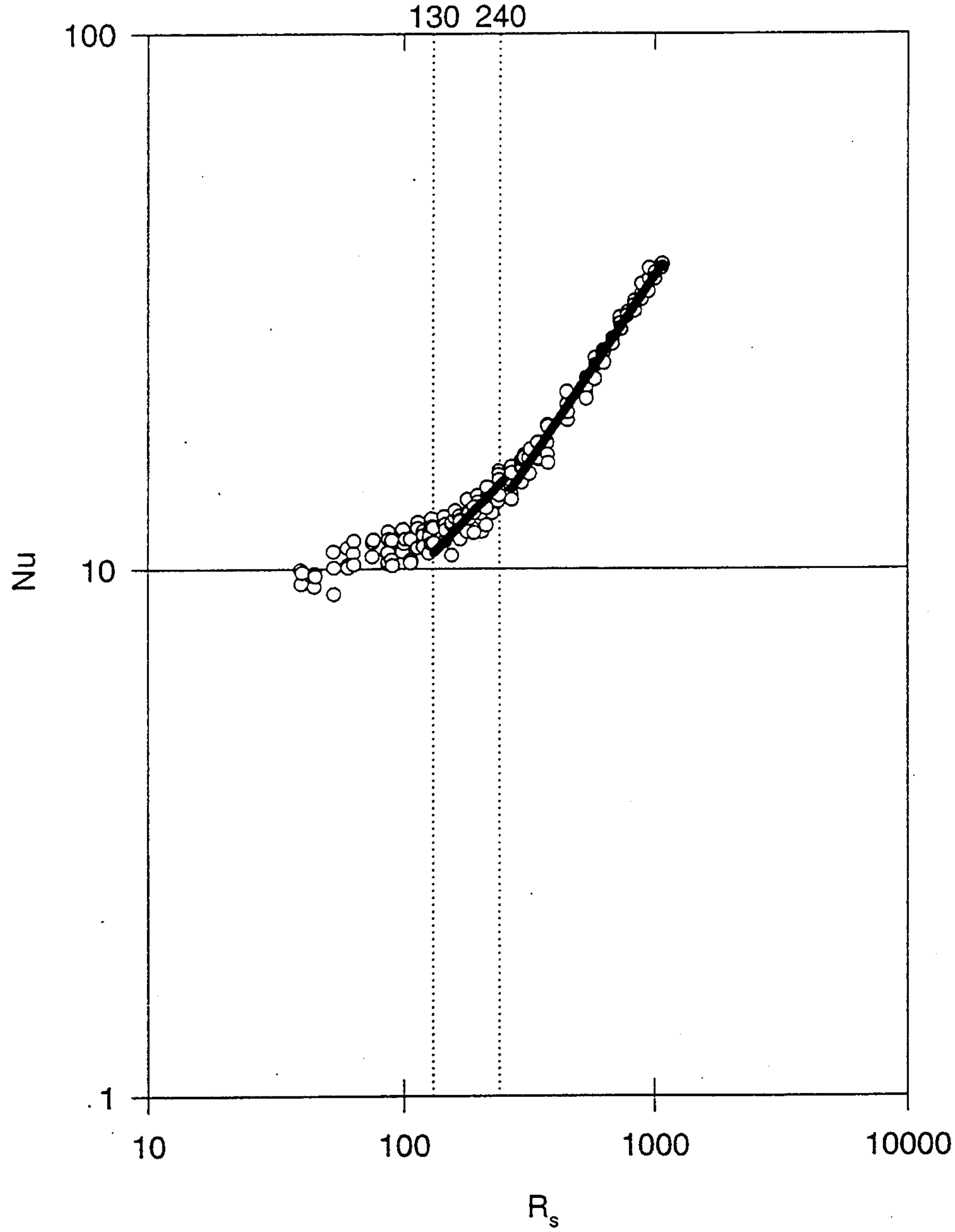

Figure 19. Data Plotted with Curve Fits for the Regimes of Interest.

# VI. RECOMMENDATIONS

Several directions for further study may be suggested by the data obtained from this work. One factor which may need further investigation is a study of the effects of varying the aspect ratio of the chamber diameter to the cylinder length to determine whether it was large enough for these experiments. A ratio of 15 was used for this experiment, and was assumed to be large enough to discount flow effects caused by the walls of the chamber, but this number was chosen somewhat arbitrarily and only a detailed experimental study can determine the actual effect.

Another possible source of error which cannot be accurately accounted for concerns itself with the experimental method used. Specifically, the measurement of the ambient temperature within the chamber at the time of each experimental trial. The method used, that of removing the test cylinder from the sound chamber after its temperature has been recorded and the acoustic signal has ceased, then placing a thermocouple through the hole it has just evacuated in the chamber wall, can be improved upon. During the time required while waiting for the thermocouple temperature to peak, the heated air in the sound chamber is rising to the top of the chamber and the accuracy of correlating the thermocouple temperature reading to that of the ambient temperature at the time of the experimental trial is left in doubt. A better method would be to permanently affix the thermocouple in the chamber so that simultaneous measurement of both the cylinder temperature and the ambient temperature can be taken.

Additional research into three different areas of the problem come to mind. First, a test of the effects of placing the test cylinder horizontally in the sound chamber is suggested, although there should be little if any dependency on this orientation since natural convection effects are small for the strong acoustic fields being used. Completely new geometries may also be tested which would mimic actual heat exchanger component shapes expected in a thermoacoustic engine. Finally, additional research using different gases in the sound chamber would provide data on the dependency of the Nusselt number on the Prandtl number.

# APPENDIX A. CALIBRATIONS AND CALCULATIONS

Several pieces of the experimental apparatus required some form of calibration, or calculation of a specific parameter, prior to initiating the experiments. The most important equipment items of concern were the "unattached" J-type thermocouples which were to be used for various applications throughout the experiment, as well as the thermocouple which was embedded in the cartridge heater. In addition, an equivalent thermal resistance for the cartridge heater/silicon oil/copper sheath circuit needed to be calculated along with assurances that the linear temperature distribution along the test cylinder was within reasonable limits. An additional study was performed to analyze the heat transfer effects on the test cylinder due only to natural convection.

Three J-type thermocouples were used throughout the experiment and were the first items to be calibrated. Since accurate temperature information was crucial to the reliability of the data obtained through experimentation, the thermocouples were tested to see if any of them showed a tendency to read either higher or lower than the actual temperature (a somewhat common occurrence). The embedded thermocouple in the cartridge heater was also tested for the same reason. All thermocouple leads were attached to the thermocouple reader to be used throughout the experiment to ensure that the entire circuit was tested concurrently.

The unattached thermocouples and the cartridge heater were all placed in an ethyl glycol solution belonging to a Rosemont Model 913A calibration bath. A Rosemont Model 920A commutating bridge, which utilizes a precision temperature probe as its input, provides the reference temperature. The temperature of the bath was then set at varying points between 22° and 48°C, the expected experimental temperatures being well within that range. Table 2 shows the results of the calibration. All thermocouples were found to read within 0.1°C of the reference temperature for all cases. This was well within the possible uncertainty of 0.5°C listed for J-type thermocouples.

Next, Figure 20 shows the thermocouple arrangement which was used to experimentally derive the equivalent thermal resistance and the linear temperature

| Reference Temperature (C) | Cartridge Heater (C) | Thermocouple "A" (C) | Thermocouple "B" (C) | Thermocouple "C" (C) | Maximum Deviation (C) |
|---|---|---|---|---|---|
| 22.83 | 22.8 | 22.8 | 22.8 | 22.8 | < 0.1 |
| 23.96 | 23.9 | 23.9 | 23.9 | 23.9 | < 0.1 |
| 26.83 | 26.8 | 26.8 | 26.8 | 26.8 | < 0.1 |
| 29.63 | 29.6 | 29.6 | 29.6 | 29.6 | < 0.1 |
| 32.49 | 32.5 | 32.5 | 32.5 | 32.5 | < 0.1 |
| 35.37 | 35.4 | 35.4 | 35.4 | 35.4 | < 0.1 |
| 38.04 | 38.1 | 38.0 | 38.0 | 38.0 | < 0.1 |
| 40.74 | 40.8 | 40.8 | 40.8 | 40.8 | < 0.1 |
| 43.02 | 43.0 | 43.0 | 43.0 | 43.0 | < 0.1 |
| 45.68 | 45.7 | 45.7 | 45.7 | 45.7 | < 0.1 |
| 48.19 | 48.2 | 48.2 | 48.2 | 48.2 | < 0.1 |

Table 2: Thermocouple Calibration Data (all values in °C)

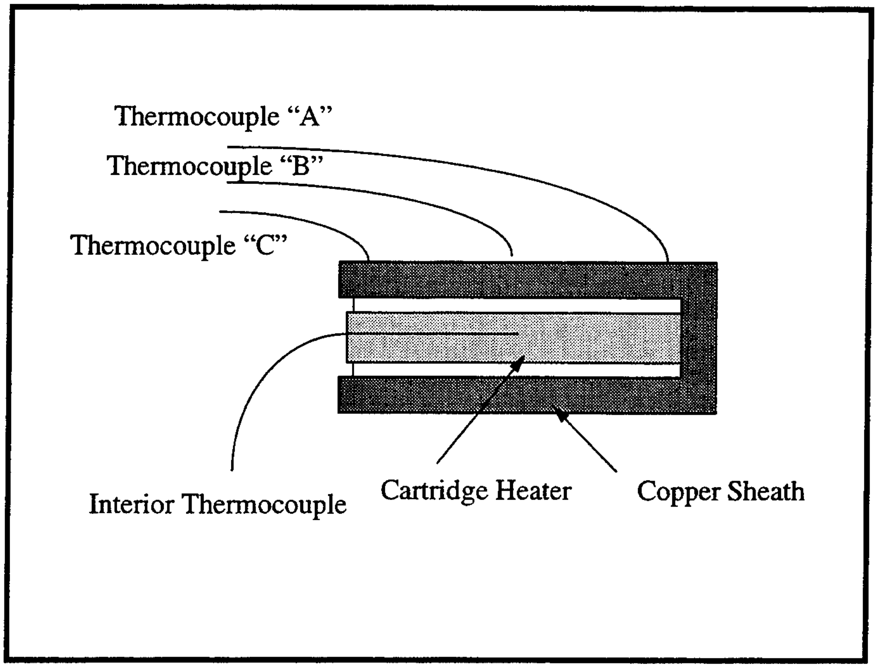

Figure 20. Thermocouple Arrangement for Calibration Tests.

distribution data. The three unattached thermocouples which were previously calibrated were securely placed on the outer surface of the test cylinder using clamps, the test cylinder being already prepared as it normally would for an experimental run. The test cylinder was then suspended horizontally and power was supplied to the cartridge heater. Once all four of the thermocouples reached a steady-state temperature, the temperatures were recorded along with the voltage and current being supplied to the heater. The equivalent thermal resistance was then derived using the equation

$$R_{eq} = \frac{T_c - T_s}{IV} \tag{A.1}$$

Temperatures which were to be comparable with those used during the experiments were obtained in a still air environment. Some additional tests were performed using a fan blowing air across the test cylinder to create a higher heat transfer rate away from the cylinder so that higher power levels to the heater could be reached while staying within the limits of the expected temperature range. An average temperature was then obtained using all three thermocouples, and this value was in turn utilized to derive an equivalent thermal resistance for each test run. The final value of the thermal resistance resulted in averaging the values from each test run, obtaining 1.022 K/W with a maximum deviation of 0.089 K/W. The results are annotated in Table 3.

The same test results were used to determine the change in temperature along the length of the test cylinder. The difference in temperature along the length at the lower power settings demonstrated a fairly even distribution of heat, with a variation of less than 0.6°C. This variation increased as the power to the heater was also increased, as could be expected. For the temperature range in which the experiments were run (again, 26° to 40° C), a maximum variation of 1.6°C occurred, although this was at a very high level of power being supplied to the heater and was not representative of the remaining data.

| Current (Amps) | Voltage (Volts) | Power (Watts) | Interior Temp (C) | Thermo-couple “A” (C) | Thermo-couple “B” (C) | Thermo-couple “C” (C) | Average Surf Temp (C) | Equiv Resistance (C) |
|---|---|---|---|---|---|---|---|---|
| 0.08 | 8.30 | 0.664 | 38.4 | 37.8 | 38.1 | 37.3 | 37.73 | 1.009 |
| 0.07 | 7.40 | 0.518 | 36.0 | 35.5 | 35.5 | 35.4 | 35.47 | 1.023 |
| 0.08 | 8.40 | 0.672 | 37.3 | 36.9 | 36.8 | 36.3 | 36.67 | 0.938 |
| 0.09 | 9.50 | 0.855 | 40.8 | 40.2 | 40.1 | 39.5 | 39.93 | 1.018 |
| 0.09 | 10.30 | 0.927 | 42.9 | 42.3 | 42.0 | 41.5 | 41.93 | 1.046 |
| 0.10 | 10.70 | 1.070 | 44.8 | 44.2 | 43.7 | 43.2 | 43.70 | 1.028 |
| 0.08 | 9.00 | 0.720 | 27.4 | 26.9 | 26.6 | 26.3 | 26.60 | 1.111 |
| 0.09 | 10.00 | 0.900 | 28.6 | 27.9 | 27.8 | 27.2 | 27.63 | 1.078 |
| 0.10 | 11.00 | 1.100 | 30.1 | 29.3 | 29.2 | 28.6 | 29.03 | 0.973 |
| 0.11 | 12.00 | 1.320 | 31.5 | 30.5 | 30.5 | 29.6 | 30.20 | 0.985 |
| 0.14 | 15.50 | 2.170 | 37.6 | 35.7 | 36.0 | 34.4 | 35.37 | 1.028 |

Table 3: Thermal Resistance and Linear Temperature Distribution Trials

# APPENDIX B. UNCERTAINTY ERROR ANALYSIS

In order to obtain a measure of the reliability of the data obtained during experimentation, an uncertainty error analysis was performed for both the Nusselt number and the streaming Reynolds number. The analysis consisted of finding the maximum possible deviation for all components appearing in the equations which define both parameters. Then, in a standard fashion, a root mean square analysis was performed to derive a reasonable overall possible error for each experimental run. The error analysis formulae were themselves incorporated into the "results worksheet" provided in Appendix C so that each data point has an associated possible error derived from the input provided.

The Nusselt number can be derived as shown from Eqs. 37 through 40

$$Nu = \frac{IV}{\pi kl(T_c - IVR_{eq} - T_a)} \tag{B.1}$$

where $l$ is the length of the test cylinder.

Using the manufacturers' recommended equipment error ranges, the maximum uncertainty in each measured component in Eq. B.1 is as follows

$$V = 0.05\%\ reading + 0.02\%\ full\ scale + 1\ digit \tag{B.2}$$

$$I = 0.5\%\ RDG + 1\ digit \tag{B.3}$$

$$T_c = \pm 0.5^o\ C \tag{B.4}$$

$$T_a = \pm 0.5^o\ C \tag{B.5}$$

The maximum uncertainty in the equivalent resistance is obtained from the calibration data in Appendix A as

$$R_{eq} = \pm 0.089 \ K/W \tag{B.6}$$

The analysis for the overall uncertainty itself is structured as follows. For the Nusselt number, the root mean square error is given by

$$\triangle(Nu) = [\sum_i (\frac{\partial Nu}{\partial X_i} \triangle X_i)^2]^{½} \tag{B.7}$$

where $X_i$ represents each individual component of Eq. B.1. The $\frac{\partial Nu}{\partial X_i}$ term, as the partial derivative indicates, physically represents the sensitivity of the Nusselt number to the variable $X_i$, provided all other variables are unchanged. The $\triangle X_i$ represents the uncertainty in the corresponding variable as given in Eqs. B.2 to B.5. For instance, the contribution to the uncertainty due to the voltage measurement is

$$(\triangle Nu)_V = \frac{\partial Nu}{\partial V} \triangle V = Nu \frac{(T_c - T_a)(\triangle V)}{V(T_c - VIR_{eq} - T_a)} \tag{B.8}$$

A value with more significance, though, is the individual fractional uncertainty which takes into account the calculated value of the Nusselt number and can be expressed as a percentage possible error. This is represented by dividing the individual uncertainty by the Nusselt number in the following manner

$$individual \ fractional \ uncertainty = \frac{(\triangle Nu)_V}{Nu} = \frac{(T_c - T_a)(\triangle V)}{V(T_c - VIR_{eq} - T_a)} \tag{B.9}$$

This new term leads directly to the desired method of expressing the possible error in the calculated value of the Nusselt number as an overall fractional uncertainty using a root mean square analysis.

$$\frac{\triangle(Nu)}{Nu} = [\sum_i (\frac{\triangle(Nu)_i}{Nu})^2]^{½} \tag{B.10}$$

In a similar fashion, the individual fractional uncertainty of the remaining terms are as follows

$$\frac{(\triangle Nu)_I}{Nu} = \frac{(T_c - T_a)(\triangle I)}{I(T_c - VIR_{eq} - T_a)} \tag{B.11}$$

$$\frac{(\triangle Nu)_{T_c}}{Nu} = \frac{(\triangle T_c)}{(T_c - VIR_{eq} - T_a)} \tag{B.12}$$

$$\frac{(\triangle Nu)_{T_a}}{Nu} = \frac{(\triangle T_a)}{(T_c - VIR_{eq} - T_a)} \tag{B.13}$$

$$\frac{(\triangle Nu)_{R_{eq}}}{Nu} = \frac{VI(\triangle R_{eq})}{(T_c - VIR_{eq} - T_a)} \tag{B.14}$$

By examining the data results, the largest contributor to the overall error in the Nusselt number is due to the current. This is caused by the small currents being utilized during the experiment, which were as low as 0.05 amps. Since the uncertainty in the current is of the order of 0.01 amps, there can be an error in the calculated Nusselt number of approximately 20% due to the current term alone. One way to lessen the effect that the current term has on the overall error is by decreasing the voltage output of the power supply and hence increasing the current needed to maintain the same power being generated. This capability, though, is not a feature of the equipment being used. It must also be noted that although $\triangle T_{c,a} = \pm 0.5^o\ C$in Eqs. B.4 and B.5, the calibration of the thermocouples described in Appendix A indicated an error of less than 0.1°C for the temperature range of the experiment. If this is taken into account, the error due to the ambient temperature ($T_a$) and the center temperature ($T_c$) terms in Eq. B.1 would diminish by 80%.

The error analysis for the streaming Reynolds number is similar to that just performed for the Nusselt number. Utilizing Eq. 17 and substituting Eqs. 33 and 41 into it, the value of $R_s$ can be shown to be

$$R_s = \frac{R(T_a + 273.15)(V_0/\sqrt{2})^2}{2\pi f \nu \gamma P_m{}^2 (0.523)^2} \tag{B.15}$$

Recall that $V_0/\sqrt{2}$ is the multimeter output voltage as derived from the pressure transducer after being passed through the 100 gain preamplifier. Thus, $R_s$ becomes a function of only the following measured variables: the frequency, the ambient temperature and the pressure transducer output as read on the multimeter, while all additional parameters remain constant. The maximum uncertainty for the thermocouple is the same as previously listed (±0.5°C) while the other two variables have uncertainties provided in the manufacturers' specifications. Calibration data for the pressure transducer used during the experiment indicates an uncertainty equivalent to 0.15% of the percentage of Full Scale Output (FSO) where the FSO is 254 mV. This correlates to a maximum deviation of 2.3 mV after passing through the 100 gain preamplifier. In addition to this, the multimeter which is used to read this voltage has an error of 0.06% reading + 0.03% Range. These combine to give a total microphone voltage output error of

$$Mic = 2.3\ mV + 0.06\%\ reading + 0.03\%\ range \tag{B.16}$$

The uncertainty in the frequency signal from the function generator error is given as 20 ppm, i.e.,

$$f = 20x10^{-6}\ reading \tag{B.17}$$

Again a root mean square analysis was performed in a manner similar to Eq. B.7 to derive the overall fractional uncertainty for the streaming Reynolds number.

$$\frac{\Delta(R_s)}{R_s} = [\sum_i (\frac{\Delta(R_s)_i}{R_s})^2]^{½} \tag{B.18}$$

The individual fractional uncertainties are

$$\frac{(\Delta R_s)_{T_a}}{R_s} = \frac{\Delta T_a}{(T_a + 273.15)} \tag{B.19}$$

$$\frac{(\Delta R_s)_{Mic}}{R_s} = \frac{2(\Delta Mic)}{V_0/\sqrt{2}} \tag{B.20}$$

$$\frac{(\Delta R_s)_f}{R_s} = \frac{\Delta f}{f} \tag{B.21}$$

The largest contribution to the error in the streaming Reynolds number is the error due to the microphone output voltage, specifically, the possible error in the pressure transducer itself. However, the data presented in Appendix C shows that this error is very small and in the range of <2% of the total value.

# APPENDIX C. EXPERIMENTAL DATA

The following pages contain the data obtained through experimentation in spreadsheet fashion. All of the relevant parameters are listed, although some constants have been left out due to size constraints.

| Experiment Information | T a (C) | T tc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h (W/m^2K) | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | $\frac{Gr}{Rs*Rs}$ | $\frac{Rs}{\Lambda}$ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 583 | 23.2 | 29 | 28.6 | 5.38 | 0.06 | 6.8 | 582 | 0.702 | 183 | 62.31 | 181 | 12.2 | 0.027 | 0.351 | 1.104 | 1484 | 944.6 | 0.005 | 4.692 | 1.3244 | 153.5 |
| L = 73 cm | 22.7 | 29.4 | 28.9 | 6.19 | 0.07 | 7.13 | 582 | 0.703 | 183 | 66.29 | 181 | 13 | 0.027 | 0.352 | 1.105 | 1484 | 944.6 | 0.005 | 4.704 | 1.3263 | 153.5 |
| PR ~ 1.3 | 22.9 | 30.3 | 29.8 | 6.86 | 0.07 | 7.55 | 582 | 0.703 | 184 | 63.34 | 181 | 12.4 | 0.027 | 0.352 | 1.105 | 1484 | 944.6 | 0.006 | 4.705 | 1.3263 | 153.5 |
|  |  |  |  |  |  |  |  |  |  | 63.98 | 181 | 12.5 | 0.027 | 0.352 | 1.105 | 1484 | 944.6 | 0.005 | 4.7 |  |  |
|  | 23.1 | 34.6 | 33.7 | 10.6 | 0.09 | 9.53 | 582 | 0.703 | 184 | 66.38 | 181 | 13 | 0.027 | 0.352 | 1.105 | 1484 | 944.6 | 0.009 | 4.705 | 1.3263 | 153.5 |
|  | 23.2 | 34.5 | 33.6 | 10.4 | 0.09 | 9.41 | 583 | 0.702 | 183 | 66.73 | 181 | 13 | 0.027 | 0.351 | 1.102 | 1486 | 946.2 | 0.009 | 4.694 | 1.3244 | 153.5 |
|  | 23.4 | 35.4 | 34.5 | 11.1 | 0.09 | 9.78 | 583 | 0.703 | 184 | 65.19 | 181 | 12.7 | 0.027 | 0.351 | 1.104 | 1486 | 946.2 | 0.009 | 4.708 | 1.3263 | 153.5 |
|  |  |  |  |  |  |  |  |  |  | 66.1 | 181 | 12.9 | 0.027 | 0.351 | 1.104 | 1485 | 945.7 | 0.009 | 4.702 |  |  |
|  | 23.5 | 39.1 | 38 | 14.5 | 0.1 | 11.24 | 583 | 0.703 | 184 | 63.94 | 182 | 12.5 | 0.027 | 0.352 | 1.104 | 1486 | 946.2 | 0.012 | 4.708 | 1.3263 | 153.5 |
|  | 23.8 | 40.8 | 39.5 | 15.7 | 0.11 | 11.82 | 583 | 0.703 | 184 | 68.21 | 182 | 13.3 | 0.027 | 0.352 | 1.105 | 1486 | 946.2 | 0.013 | 4.709 | 1.3263 | 153.5 |
|  | 24.1 | 40 | 38.8 | 14.7 | 0.1 | 11.51 | 583 | 0.702 | 184 | 64.27 | 181 | 12.6 | 0.027 | 0.351 | 1.104 | 1486 | 946.2 | 0.012 | 4.696 | 1.3244 | 153.5 |
|  |  |  |  |  |  |  |  |  |  | 65.47 | 181 | 12.8 | 0.027 | 0.352 | 1.104 | 1486 | 946.2 | 0.012 | 4.704 |  |  |
| f ~ 583 | 23.6 | 32.2 | 31.3 | 7.74 | 0.09 | 9.36 | 583 | 0.906 | 305 | 89.48 | 301 | 17.5 | 0.027 | 0.453 | 1.423 | 1486 | 946.2 | 0.002 | 7.82 | 1.7092 | 155.7 |
| L = 73 cm | 23.7 | 31.5 | 30.8 | 7.08 | 0.08 | 8.77 | 583 | 0.905 | 305 | 81.43 | 301 | 15.9 | 0.027 | 0.453 | 1.422 | 1486 | 946.2 | 0.002 | 7.803 | 1.7074 | 155.7 |
| PR ~ 1.7 | 23.7 | 31.8 | 31.1 | 7.37 | 0.08 | 8.94 | 583 | 0.905 | 305 | 79.79 | 301 | 15.6 | 0.027 | 0.453 | 1.422 | 1486 | 946.2 | 0.002 | 7.803 | 1.7074 | 155.7 |
|  |  |  |  |  |  |  |  |  |  | 83.57 | 301 | 16.3 | 0.027 | 0.453 | 1.423 | 1486 | 946.2 | 0.002 | 7.808 |  |  |
|  | 24 | 35.5 | 34.4 | 10.4 | 0.1 | 10.75 | 583 | 0.902 | 303 | 84.96 | 299 | 16.6 | 0.027 | 0.451 | 1.418 | 1486 | 946.2 | 0.003 | 7.752 | 1.7017 | 155.7 |
|  | 24.3 | 36.1 | 35 | 10.7 | 0.1 | 10.93 | 584 | 0.903 | 303 | 84.11 | 300 | 16.4 | 0.027 | 0.451 | 1.418 | 1489 | 947.9 | 0.003 | 7.773 | 1.7036 | 155.7 |
|  | 24.5 | 36.2 | 35.1 | 10.6 | 0.1 | 10.86 | 584 | 0.903 | 304 | 84.3 | 300 | 16.5 | 0.027 | 0.452 | 1.418 | 1489 | 947.9 | 0.003 | 7.774 | 1.7036 | 155.7 |
|  |  |  |  |  |  |  |  |  |  | 84.46 | 300 | 16.5 | 0.027 | 0.451 | 1.418 | 1488 | 947.3 | 0.003 | 7.767 |  |  |
|  | 24.2 | 39.8 | 38.4 | 14.2 | 0.11 | 12.7 | 584 | 0.904 | 304 | 81.04 | 301 | 15.8 | 0.027 | 0.452 | 1.419 | 1489 | 947.9 | 0.004 | 7.79 | 1.7055 | 155.7 |
|  | 24.5 | 41.2 | 39.6 | 15.1 | 0.12 | 13.15 | 584 | 0.904 | 304 | 85.98 | 301 | 16.8 | 0.027 | 0.452 | 1.42 | 1489 | 947.9 | 0.004 | 7.791 | 1.7055 | 155.7 |
|  | 24.7 | 41.3 | 39.7 | 15 | 0.12 | 13 | 584 | 0.905 | 305 | 85.46 | 301 | 16.7 | 0.027 | 0.453 | 1.422 | 1489 | 947.9 | 0.004 | 7.809 | 1.7074 | 155.7 |
|  |  |  |  |  |  |  |  |  |  | 84.16 | 301 | 16.4 | 0.027 | 0.452 | 1.42 | 1489 | 947.9 | 0.004 | 7.797 |  |  |
| f ~ 583 | 22.9 | 30.6 | 29.7 | 6.83 | 0.09 | 9.46 | 582 | 1.104 | 453 | 102.5 | 447 | 20 | 0.027 | 0.552 | 1.735 | 1484 | 944.6 | 9E-04 | 11.6 | 2.0828 | 157.5 |
| L = 73 cm | 23.2 | 31.6 | 30.7 | 7.49 | 0.09 | 9.92 | 582 | 1.099 | 449 | 98.02 | 443 | 19.2 | 0.027 | 0.55 | 1.728 | 1484 | 944.6 | 0.001 | 11.5 | 2.0733 | 157.4 |
| PR ~ 2.1 | 23.4 | 31.5 | 30.6 | 7.2 | 0.09 | 9.8 | 583 | 1.107 | 455 | 100.7 | 450 | 19.7 | 0.027 | 0.553 | 1.739 | 1486 | 946.2 | 1E-03 | 11.67 | 2.0884 | 157.5 |
|  |  |  |  |  |  |  |  |  |  | 100.4 | 447 | 19.6 | 0.027 | 0.552 | 1.734 | 1485 | 945.2 | 1E-03 | 11.59 |  |  |
|  | 23.7 | 36.2 | 34.8 | 11.1 | 0.11 | 12.16 | 583 | 1.106 | 455 | 98.77 | 449 | 19.3 | 0.027 | 0.553 | 1.738 | 1486 | 946.2 | 0.001 | 11.65 | 2.0866 | 157.5 |
|  | 23.9 | 35.7 | 34.4 | 10.5 | 0.11 | 11.86 | 583 | 1.107 | 456 | 102.5 | 450 | 20 | 0.027 | 0.554 | 1.74 | 1486 | 946.2 | 0.001 | 11.68 | 2.0884 | 157.5 |
|  | 23.9 | 35.5 | 34.2 | 10.3 | 0.11 | 11.73 | 583 | 1.107 | 456 | 103.2 | 450 | 20.2 | 0.027 | 0.554 | 1.74 | 1486 | 946.2 | 0.001 | 11.68 | 2.0884 | 157.5 |
|  |  |  |  |  |  |  |  |  |  | 101.6 | 450 | 19.8 | 0.027 | 0.554 | 1.739 | 1486 | 946.2 | 0.001 | 11.67 |  |  |
|  | 24.2 | 39.9 | 38.2 | 14 | 0.12 | 13.66 | 583 | 1.103 | 453 | 96.08 | 447 | 18.8 | 0.027 | 0.552 | 1.735 | 1486 | 946.2 | 0.002 | 11.59 | 2.0809 | 157.5 |
|  | 24.3 | 40.3 | 38.6 | 14.3 | 0.12 | 13.89 | 584 | 1.107 | 456 | 95.84 | 451 | 18.7 | 0.027 | 0.553 | 1.738 | 1489 | 947.9 | 0.002 | 11.68 | 2.0884 | 157.5 |
|  | 24.5 | 41.3 | 39.4 | 14.9 | 0.13 | 14.28 | 584 | 1.107 | 456 | 102.4 | 451 | 20 | 0.027 | 0.554 | 1.739 | 1489 | 947.9 | 0.002 | 11.68 | 2.0884 | 157.5 |
|  |  |  |  |  |  |  |  |  |  | 98.11 | 450 | 19.2 | 0.027 | 0.553 | 1.737 | 1488 | 947.3 | 0.002 | 11.65 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | I uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 583 | 0.2123 | 18.493 | 9.2866 | 9.2866 | 0.6972 | 22.693 | 0.1687 | 0.9402 | 0.002 | 0.9552 |
| L = 73 cm | 0.2059 | 16.001 | 8.0759 | 8.0759 | 0.7416 | 19.674 | 0.169 | 0.9388 | 0.002 | 0.9539 |
| PR ~ 1.3 | 0.1968 | 15.947 | 7.2873 | 7.2873 | 0.7086 | 19.001 | 0.1689 | 0.9388 | 0.002 | 0.9539 |
|  |  |  |  |  |  | 20.456 |  |  |  | 0.9543 |
|  | 0.1677 | 12.567 | 4.7056 | 4.7056 | 0.7426 | 14.24 | 0.1688 | 0.9388 | 0.002 | 0.9539 |
|  | 0.1692 | 12.572 | 4.7908 | 4.7908 | 0.7465 | 14.302 | 0.1687 | 0.9402 | 0.002 | 0.9552 |
|  | 0.1646 | 12.549 | 4.5034 | 4.5034 | 0.7294 | 14.093 | 0.1686 | 0.9388 | 0.002 | 0.9539 |
|  |  |  |  |  |  | 14.212 |  |  |  | 0.9543 |
|  | 0.15 | 11.332 | 3.4592 | 3.4592 | 0.7154 | 12.365 | 0.1685 | 0.9388 | 0.002 | 0.9538 |
|  | 0.146 | 10.402 | 3.1899 | 3.1899 | 0.7631 | 11.365 | 0.1684 | 0.9388 | 0.002 | 0.9538 |
|  | 0.1478 | 11.337 | 3.3952 | 3.3952 | 0.719 | 12.333 | 0.1682 | 0.9402 | 0.002 | 0.9551 |
|  |  |  |  |  |  | 12.021 |  |  |  | 0.9543 |
| f ~ 583 | 0.1742 | 12.899 | 6.4589 | 6.4589 | 1.0011 | 15.838 | 0.1685 | 0.7285 | 0.002 | 0.7477 |
| L = 73 cm | 0.1806 | 14.312 | 7.0574 | 7.0574 | 0.9111 | 17.473 | 0.1684 | 0.7293 | 0.002 | 0.7485 |
| PR ~ 1.7 | 0.1779 | 14.286 | 6.7834 | 6.7834 | 0.8927 | 17.232 | 0.1684 | 0.7293 | 0.002 | 0.7485 |
|  |  |  |  |  |  | 16.848 |  |  |  | 0.7482 |
|  | 0.1581 | 11.606 | 4.8058 | 4.8058 | 0.9506 | 13.484 | 0.1683 | 0.7317 | 0.002 | 0.7508 |
|  | 0.1562 | 11.595 | 4.6791 | 4.6791 | 0.941 | 13.384 | 0.1681 | 0.7309 | 0.002 | 0.75 |
|  | 0.1569 | 11.597 | 4.7201 | 4.7201 | 0.9432 | 13.415 | 0.168 | 0.7309 | 0.002 | 0.75 |
|  |  |  |  |  |  | 13.428 |  |  |  | 0.7502 |
|  | 0.1417 | 10.554 | 3.5271 | 3.5271 | 0.9066 | 11.71 | 0.1682 | 0.7301 | 0.002 | 0.7492 |
|  | 0.1395 | 9.7749 | 3.3131 | 3.3131 | 0.962 | 10.883 | 0.168 | 0.7301 | 0.002 | 0.7492 |
|  | 0.1404 | 9.7692 | 3.3312 | 3.3312 | 0.9562 | 10.889 | 0.1679 | 0.7293 | 0.002 | 0.7484 |
|  |  |  |  |  |  | 11.161 |  |  |  | 0.7489 |
| f ~ 583 | 0.1755 | 13.086 | 7.3184 | 7.3184 | 1.1465 | 16.724 | 0.1689 | 0.5978 | 0.002 | 0.6212 |
| L = 73 cm | 0.1691 | 13.022 | 6.6756 | 6.6756 | 1.0966 | 16.122 | 0.1687 | 0.6005 | 0.002 | 0.6238 |
| PR ~ 2.1 | 0.171 | 13.061 | 6.9436 | 6.9436 | 1.1269 | 16.38 | 0.1686 | 0.5962 | 0.002 | 0.6196 |
|  |  |  |  |  |  | 16.409 |  |  |  | 0.6215 |
|  | 0.1484 | 10.765 | 4.4897 | 4.4897 | 1.105 | 12.548 | 0.1684 | 0.5967 | 0.002 | 0.6201 |
|  | 0.1514 | 10.809 | 4.7755 | 4.7755 | 1.1463 | 12.798 | 0.1683 | 0.5962 | 0.002 | 0.6195 |
|  | 0.1525 | 10.817 | 4.8616 | 4.8616 | 1.1542 | 12.87 | 0.1683 | 0.5962 | 0.002 | 0.6195 |
|  |  |  |  |  |  | 12.739 |  |  |  | 0.6197 |
|  | 0.1379 | 9.8854 | 3.564 | 3.564 | 1.075 | 11.149 | 0.1682 | 0.5984 | 0.002 | 0.6215 |
|  | 0.1365 | 9.8828 | 3.4963 | 3.4963 | 1.0723 | 11.103 | 0.1681 | 0.5962 | 0.002 | 0.6195 |
|  | 0.1353 | 9.2322 | 3.354 | 3.354 | 1.1456 | 10.443 | 0.168 | 0.5962 | 0.002 | 0.6194 |
|  |  |  |  |  |  | 10.899 |  |  |  | 0.6201 |

| Experiment Information | T a (C) | T tc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs/Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 584 | 24 | 31.6 | 30.5 | 6.52 | 0.1 | 10.61 | 584 | 1.305 | 633 | 133.8 | 626 | 26.2 | 0.027 | 0.652 | 2.048 | 1489 | 947.9 | 4E-04 | 16.23 | 2.462 | 158.9 |
| L = 73 cm | 24.1 | 32.2 | 31.1 | 6.99 | 0.1 | 10.85 | 584 | 1.303 | 631 | 127.6 | 624 | 24.9 | 0.027 | 0.651 | 2.045 | 1489 | 947.9 | 5E-04 | 16.18 | 2.4582 | 158.9 |
| PR ~ 2.5 | 24.3 | 32.1 | 31 | 6.71 | 0.1 | 10.66 | 584 | 1.304 | 633 | 130.6 | 625 | 25.5 | 0.027 | 0.652 | 2.048 | 1489 | 947.9 | 4E-04 | 16.21 | 2.4601 | 158.9 |
|  |  |  |  |  |  |  |  |  |  | 130.7 | 625 | 25.5 | 0.027 | 0.652 | 2.047 | 1489 | 947.9 | 5E-04 | 16.21 |  |  |
|  | 24.5 | 35.9 | 34.3 | 9.81 | 0.12 | 12.97 | 584 | 1.302 | 631 | 130.4 | 624 | 25.5 | 0.027 | 0.651 | 2.045 | 1489 | 947.9 | 7E-04 | 16.16 | 2.4563 | 158.9 |
|  | 24.7 | 36.8 | 35.2 | 10.5 | 0.12 | 13.24 | 584 | 1.3 | 630 | 124.7 | 622 | 24.4 | 0.027 | 0.65 | 2.043 | 1489 | 947.9 | 7E-04 | 16.11 | 2.4526 | 158.9 |
|  | 24.8 | 37.1 | 35.5 | 10.7 | 0.12 | 13.4 | 584 | 1.3 | 630 | 124 | 622 | 24.2 | 0.027 | 0.65 | 2.043 | 1489 | 947.9 | 7E-04 | 16.11 | 2.4526 | 158.9 |
|  |  |  |  |  |  |  |  |  |  | 126.4 | 622 | 24.7 | 0.027 | 0.651 | 2.044 | 1489 | 947.9 | 7E-04 | 16.13 |  |  |
|  | 25.1 | 40.7 | 38.5 | 13.4 | 0.14 | 15.27 | 585 | 1.305 | 634 | 131 | 627 | 25.6 | 0.027 | 0.652 | 2.048 | 1491 | 949.5 | 9E-04 | 16.25 | 2.462 | 158.9 |
|  | 25.2 | 40.4 | 38.4 | 13.2 | 0.13 | 15.04 | 585 | 1.303 | 632 | 121.7 | 626 | 23.8 | 0.027 | 0.651 | 2.046 | 1491 | 949.5 | 9E-04 | 16.2 | 2.4582 | 158.9 |
|  | 25.3 | 40.4 | 38.4 | 13.1 | 0.13 | 15.04 | 585 | 1.304 | 634 | 122.7 | 627 | 24 | 0.027 | 0.652 | 2.048 | 1491 | 949.5 | 8E-04 | 16.22 | 2.4601 | 158.9 |
|  |  |  |  |  |  |  |  |  |  | 125.1 | 627 | 24.4 | 0.027 | 0.652 | 2.047 | 1491 | 949.5 | 9E-04 | 16.22 |  |  |
| f ~ 584 | 24.7 | 32.6 | 31.3 | 6.56 | 0.11 | 11.93 | 585 | 1.501 | 838 | 164.4 | 830 | 32.1 | 0.027 | 0.749 | 2.355 | 1491 | 949.5 | 2E-04 | 21.49 | 2.8318 | 160.1 |
| L = 73 cm | 24.7 | 31.8 | 30.7 | 5.96 | 0.1 | 11.23 | 585 | 1.5 | 837 | 155.1 | 829 | 30.3 | 0.027 | 0.749 | 2.353 | 1491 | 949.5 | 2E-04 | 21.46 | 2.8299 | 160.1 |
| PR ~ 2.8 | 25.1 | 32.8 | 31.5 | 6.38 | 0.11 | 11.76 | 585 | 1.501 | 839 | 166.7 | 830 | 32.6 | 0.027 | 0.75 | 2.356 | 1491 | 949.5 | 2E-04 | 21.49 | 2.8318 | 160.1 |
|  |  |  |  |  |  |  |  |  |  | 162.1 | 830 | 31.7 | 0.027 | 0.749 | 2.355 | 1491 | 949.5 | 2E-04 | 21.48 |  |  |
|  | 25.1 | 37.1 | 35.2 | 10.1 | 0.13 | 14.53 | 585 | 1.5 | 838 | 154.2 | 829 | 30.1 | 0.027 | 0.749 | 2.355 | 1491 | 949.5 | 4E-04 | 21.46 | 2.8299 | 160.1 |
|  | 25.4 | 36.8 | 34.9 | 9.5 | 0.13 | 14.31 | 585 | 1.494 | 832 | 161 | 822 | 31.4 | 0.027 | 0.747 | 2.346 | 1491 | 949.5 | 4E-04 | 21.3 | 2.8185 | 160.1 |
|  | 25.4 | 37.4 | 35.4 | 10 | 0.13 | 14.74 | 585 | 1.497 | 835 | 156.8 | 826 | 30.6 | 0.027 | 0.748 | 2.351 | 1491 | 949.5 | 4E-04 | 21.38 | 2.8242 | 160.1 |
|  |  |  |  |  |  |  |  |  |  | 157.3 | 826 | 30.7 | 0.027 | 0.748 | 2.351 | 1491 | 949.5 | 4E-04 | 21.38 |  |  |
|  | 25.7 | 39.6 | 37.3 | 11.6 | 0.14 | 15.84 | 586 | 1.503 | 841 | 156.7 | 833 | 30.6 | 0.027 | 0.75 | 2.358 | 1494 | 951.1 | 4E-04 | 21.56 | 2.8355 | 160.1 |
|  | 25.9 | 40.7 | 38.4 | 12.5 | 0.14 | 16.3 | 586 | 1.5 | 839 | 150.4 | 830 | 29.4 | 0.027 | 0.749 | 2.354 | 1494 | 951.1 | 4E-04 | 21.48 | 2.8299 | 160.1 |
|  | 25.9 | 41.4 | 38.8 | 12.9 | 0.15 | 16.76 | 586 | 1.5 | 839 | 159.8 | 830 | 31.2 | 0.027 | 0.749 | 2.354 | 1494 | 951.1 | 5E-04 | 21.48 | 2.8299 | 160.1 |
|  |  |  |  |  |  |  |  |  |  | 155.6 | 831 | 30.4 | 0.027 | 0.75 | 2.355 | 1494 | 951.1 | 4E-04 | 21.51 |  |  |
| f ~ 584 | 23.2 | 30.8 | 30.1 | 6.93 | 0.08 | 8.2 | 583 | 0.804 | 240 | 77.83 | 237 | 15.2 | 0.027 | 0.402 | 1.262 | 1486 | 946.2 | 0.003 | 6.157 | 1.5168 | 154.7 |
| L = 73 cm | 23.3 | 31.1 | 30.4 | 7.11 | 0.08 | 8.52 | 583 | 0.804 | 240 | 78.88 | 237 | 15.4 | 0.027 | 0.402 | 1.263 | 1486 | 946.2 | 0.003 | 6.157 | 1.5168 | 154.7 |
| PR ~ 1.5 | 23.3 | 31.4 | 30.7 | 7.41 | 0.08 | 8.52 | 583 | 0.804 | 240 | 75.69 | 237 | 14.8 | 0.027 | 0.402 | 1.263 | 1486 | 946.2 | 0.004 | 6.157 | 1.5168 | 154.7 |
|  |  |  |  |  |  |  |  |  |  | 77.47 | 237 | 15.1 | 0.027 | 0.402 | 1.262 | 1486 | 946.2 | 0.003 | 6.157 |  |  |
|  | 23.6 | 35.7 | 34.6 | 11 | 0.1 | 10.59 | 583 | 0.804 | 240 | 79.02 | 237 | 15.4 | 0.027 | 0.402 | 1.263 | 1486 | 946.2 | 0.005 | 6.158 | 1.5168 | 154.7 |
|  | 23.7 | 36.1 | 35 | 11.3 | 0.1 | 10.78 | 583 | 0.803 | 240 | 78.44 | 237 | 15.3 | 0.027 | 0.402 | 1.262 | 1486 | 946.2 | 0.005 | 6.143 | 1.5149 | 154.7 |
|  | 23.9 | 36.4 | 35.3 | 11.4 | 0.1 | 10.91 | 583 | 0.804 | 241 | 78.78 | 237 | 15.4 | 0.027 | 0.402 | 1.264 | 1486 | 946.2 | 0.005 | 6.159 | 1.5168 | 154.7 |
|  |  |  |  |  |  |  |  |  |  | 78.75 | 237 | 15.4 | 0.027 | 0.402 | 1.263 | 1486 | 946.2 | 0.005 | 6.153 |  |  |
|  | 23.9 | 39.3 | 37.9 | 14 | 0.11 | 12.21 | 583 | 0.803 | 240 | 78.71 | 237 | 15.4 | 0.027 | 0.402 | 1.262 | 1486 | 946.2 | 0.007 | 6.144 | 1.5149 | 154.7 |
|  | 24.1 | 40.1 | 38.7 | 14.6 | 0.11 | 12.41 | 583 | 0.803 | 240 | 76.84 | 237 | 15 | 0.027 | 0.402 | 1.263 | 1486 | 946.2 | 0.007 | 6.144 | 1.5149 | 154.7 |
|  | 24.1 | 39.9 | 38.5 | 14.4 | 0.11 | 12.31 | 583 | 0.803 | 240 | 77.22 | 237 | 15.1 | 0.027 | 0.402 | 1.263 | 1486 | 946.2 | 0.007 | 6.144 | 1.5149 | 154.7 |
|  |  |  |  |  |  |  |  |  |  | 77.59 | 237 | 15.2 | 0.027 | 0.402 | 1.263 | 1486 | 946.2 | 0.007 | 6.144 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | To uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 584 | 0.1682 | 12.242 | 7.6705 | 7.6705 | 1.4975 | 16.426 | 0.1683 | 0.5057 | 0.002 | 0.533 |
| L = 73 cm | 0.1646 | 12.16 | 7.149 | 7.149 | 1.4272 | 15.879 | 0.1682 | 0.5065 | 0.002 | 0.5337 |
| PR ~ 2.5 | 0.1671 | 12.2 | 7.4478 | 7.4478 | 1.4608 | 16.184 | 0.1681 | 0.5061 | 0.002 | 0.5333 |
| | | | | | | 16.163 | | | | 0.5334 |
| | 0.1476 | 10.261 | 5.095 | 5.095 | 1.4591 | 12.624 | 0.168 | 0.5069 | 0.002 | 0.534 |
| | 0.1449 | 10.198 | 4.7708 | 4.7708 | 1.3947 | 12.308 | 0.1679 | 0.5077 | 0.002 | 0.5347 |
| | 0.1438 | 10.191 | 4.6901 | 4.6901 | 1.3877 | 12.24 | 0.1678 | 0.5077 | 0.002 | 0.5347 |
| | | | | | | 12.391 | | | | 0.5345 |
| | 0.1342 | 8.8839 | 3.7256 | 3.7256 | 1.4655 | 10.433 | 0.1676 | 0.5057 | 0.002 | 0.5328 |
| | 0.1341 | 9.4286 | 3.7859 | 3.7859 | 1.362 | 10.929 | 0.1676 | 0.5065 | 0.002 | 0.5335 |
| | 0.1342 | 9.438 | 3.8148 | 3.8148 | 1.3724 | 10.958 | 0.1675 | 0.5061 | 0.002 | 0.5331 |
| | | | | | | 10.773 | | | | 0.5332 |
| f ~ 584 | 0.1611 | 11.546 | 7.6193 | 7.6193 | 1.8398 | 15.901 | 0.1679 | 0.4397 | 0.002 | 0.4707 |
| L = 73 cm | 0.1658 | 12.518 | 8.396 | 8.396 | 1.7349 | 17.342 | 0.1679 | 0.44 | 0.002 | 0.4709 |
| PR ~ 2.8 | 0.1629 | 11.573 | 7.8353 | 7.8353 | 1.865 | 16.131 | 0.1676 | 0.4397 | 0.002 | 0.4706 |
| | | | | | | 16.458 | | | | 0.4707 |
| | 0.1415 | 9.7581 | 4.963 | 4.963 | 1.7249 | 12.144 | 0.1676 | 0.44 | 0.002 | 0.4709 |
| | 0.1438 | 9.827 | 5.2611 | 5.2611 | 1.8009 | 12.458 | 0.1675 | 0.4418 | 0.002 | 0.4725 |
| | 0.1408 | 9.7851 | 4.9768 | 4.9768 | 1.7547 | 12.181 | 0.1675 | 0.4409 | 0.002 | 0.4716 |
| | | | | | | 12.261 | | | | 0.4716 |
| | 0.1351 | 9.1272 | 4.2957 | 4.2957 | 1.7528 | 11.104 | 0.1673 | 0.4391 | 0.002 | 0.4699 |
| | 0.1321 | 9.0681 | 4.0084 | 4.0084 | 1.6831 | 10.827 | 0.1672 | 0.44 | 0.002 | 0.4707 |
| | 0.1314 | 8.5863 | 3.8648 | 3.8648 | 1.7878 | 10.335 | 0.1672 | 0.44 | 0.002 | 0.4707 |
| | | | | | | 10.755 | | | | 0.4704 |
| f ~ 584 | 0.1885 | 14.254 | 7.2137 | 7.2137 | 0.8707 | 17.551 | 0.1687 | 0.8209 | 0.002 | 0.8381 |
| L = 73 cm | 0.1837 | 14.271 | 7.0371 | 7.0371 | 0.8826 | 17.422 | 0.1687 | 0.8209 | 0.002 | 0.838 |
| PR ~ 1.5 | 0.1831 | 14.22 | 6.752 | 6.752 | 0.8468 | 17.15 | 0.1687 | 0.8209 | 0.002 | 0.838 |
| | | | | | | 17.374 | | | | 0.838 |
| | 0.1586 | 11.529 | 4.537 | 4.537 | 0.8841 | 13.224 | 0.1685 | 0.8209 | 0.002 | 0.838 |
| | 0.1566 | 11.521 | 4.4243 | 4.4243 | 0.8776 | 13.141 | 0.1684 | 0.8219 | 0.002 | 0.839 |
| | 0.1555 | 11.525 | 4.3906 | 4.3906 | 0.8814 | 13.122 | 0.1683 | 0.8209 | 0.002 | 0.838 |
| | | | | | | 13.162 | | | | 0.8383 |
| | 0.1448 | 10.527 | 3.5636 | 3.5636 | 0.8807 | 11.705 | 0.1683 | 0.8219 | 0.002 | 0.839 |
| | 0.143 | 10.504 | 3.4227 | 3.4227 | 0.8597 | 11.599 | 0.1682 | 0.8219 | 0.002 | 0.839 |
| | 0.1438 | 10.509 | 3.4675 | 3.4675 | 0.8639 | 11.63 | 0.1682 | 0.8219 | 0.002 | 0.839 |
| | | | | | | 11.645 | | | | 0.839 |

| Experiment Information | Ta (C) | Ttc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr / Rs*Rs | Rs / Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 584 | 23.8 | 30.8 | 30.1 | 6.27 | 0.08 | 8.97 | 583 | 1.006 | 376 | 94.13 | 372 | 18.4 | 0.027 | 0.503 | 1.581 | 1486 | 946.2 | 0.001 | 9.642 | 1.8979 | 156.7 |
| L = 73 cm | 23.8 | 31.8 | 30.9 | 7.13 | 0.09 | 9.46 | 583 | 1.006 | 376 | 98.16 | 372 | 19.2 | 0.027 | 0.503 | 1.581 | 1486 | 946.2 | 0.001 | 9.642 | 1.8979 | 156.7 |
| PR ~ 1.9 | 23.9 | 32.1 | 31.2 | 7.33 | 0.09 | 9.53 | 583 | 1.006 | 377 | 96.28 | 372 | 18.8 | 0.027 | 0.503 | 1.581 | 1486 | 946.2 | 0.001 | 9.642 | 1.8979 | 156.7 |
|  |  |  |  |  |  |  |  |  |  | 96.19 | 372 | 18.8 | 0.027 | 0.503 | 1.581 | 1486 | 946.2 | 0.001 | 9.642 |  |  |
|  | 24.1 | 35.6 | 34.5 | 10.4 | 0.1 | 11.19 | 583 | 1.005 | 376 | 88.82 | 371 | 17.4 | 0.027 | 0.503 | 1.58 | 1486 | 946.2 | 0.002 | 9.624 | 1.896 | 156.6 |
|  | 24.2 | 35.8 | 34.6 | 10.4 | 0.1 | 11.32 | 584 | 1.006 | 376 | 89.11 | 372 | 17.4 | 0.027 | 0.503 | 1.579 | 1489 | 947.9 | 0.002 | 9.647 | 1.8979 | 156.7 |
|  | 24.3 | 36.2 | 35 | 10.7 | 0.1 | 11.52 | 584 | 1.007 | 377 | 88.32 | 373 | 17.3 | 0.027 | 0.503 | 1.581 | 1489 | 947.9 | 0.002 | 9.667 | 1.8998 | 156.7 |
|  |  |  |  |  |  |  |  |  |  | 88.75 | 372 | 17.3 | 0.027 | 0.503 | 1.58 | 1488 | 947.3 | 0.002 | 9.646 |  |  |
|  | 24.3 | 39.2 | 37.6 | 13.3 | 0.12 | 13.02 | 584 | 1.007 | 377 | 96.55 | 373 | 18.9 | 0.027 | 0.503 | 1.581 | 1489 | 947.9 | 0.003 | 9.667 | 1.8998 | 156.7 |
|  | 24.4 | 39.9 | 38.3 | 13.9 | 0.12 | 13.41 | 584 | 1.004 | 375 | 95.48 | 371 | 18.7 | 0.027 | 0.502 | 1.577 | 1489 | 947.9 | 0.003 | 9.61 | 1.8941 | 156.6 |
|  | 24.4 | 40.3 | 38.6 | 14.2 | 0.12 | 13.64 | 584 | 1.01 | 380 | 94.58 | 375 | 18.5 | 0.027 | 0.505 | 1.586 | 1489 | 947.9 | 0.003 | 9.725 | 1.9054 | 156.7 |
|  |  |  |  |  |  |  |  |  |  | 95.53 | 373 | 18.7 | 0.027 | 0.503 | 1.581 | 1489 | 947.9 | 0.003 | 9.667 |  |  |
| f ~ 584 | 23.6 | 31.4 | 30.5 | 6.88 | 0.09 | 10.05 | 583 | 1.202 | 537 | 108.1 | 531 | 21.1 | 0.027 | 0.601 | 1.889 | 1486 | 946.2 | 7E-04 | 13.76 | 2.2677 | 158.2 |
| L = 73 cm | 23.6 | 31.7 | 30.8 | 7.16 | 0.09 | 10.3 | 583 | 1.202 | 537 | 106.5 | 531 | 20.8 | 0.027 | 0.601 | 1.889 | 1486 | 946.2 | 7E-04 | 13.76 | 2.2677 | 158.2 |
| PR ~ 2.3 | 23.8 | 32.3 | 31.2 | 7.42 | 0.1 | 10.55 | 583 | 1.2 | 536 | 116.8 | 529 | 22.8 | 0.027 | 0.6 | 1.886 | 1486 | 946.2 | 7E-04 | 13.72 | 2.2639 | 158.2 |
|  |  |  |  |  |  |  |  |  |  | 110.5 | 530 | 21.6 | 0.027 | 0.601 | 1.888 | 1486 | 946.2 | 7E-04 | 13.75 |  |  |
|  | 24 | 35.9 | 34.5 | 10.5 | 0.11 | 12.51 | 584 | 1.203 | 538 | 107.8 | 532 | 21.1 | 0.027 | 0.601 | 1.888 | 1489 | 947.9 | 1E-03 | 13.79 | 2.2696 | 158.2 |
|  | 24.2 | 36.3 | 34.9 | 10.7 | 0.11 | 12.73 | 584 | 1.202 | 537 | 107.9 | 531 | 21.1 | 0.027 | 0.601 | 1.887 | 1489 | 947.9 | 1E-03 | 13.77 | 2.2677 | 158.2 |
|  | 24.2 | 36.3 | 34.9 | 10.7 | 0.11 | 12.6 | 584 | 1.204 | 539 | 106.6 | 533 | 20.8 | 0.027 | 0.602 | 1.89 | 1489 | 947.9 | 1E-03 | 13.82 | 2.2714 | 158.2 |
|  |  |  |  |  |  |  |  |  |  | 107.4 | 532 | 21 | 0.027 | 0.601 | 1.889 | 1489 | 947.9 | 1E-03 | 13.79 |  |  |
|  | 24.5 | 40 | 38.1 | 13.6 | 0.13 | 14.49 | 584 | 1.204 | 540 | 114.1 | 533 | 22.3 | 0.027 | 0.602 | 1.891 | 1489 | 947.9 | 0.001 | 13.82 | 2.2714 | 158.2 |
|  | 24.6 | 40.4 | 38.5 | 13.9 | 0.13 | 14.66 | 584 | 1.203 | 539 | 113.1 | 532 | 22.1 | 0.027 | 0.602 | 1.89 | 1489 | 947.9 | 0.001 | 13.8 | 2.2696 | 158.2 |
|  | 24.7 | 40.8 | 38.8 | 14.1 | 0.13 | 14.82 | 584 | 1.201 | 537 | 112.1 | 531 | 21.9 | 0.027 | 0.601 | 1.887 | 1489 | 947.9 | 0.001 | 13.75 | 2.2658 | 158.2 |
|  |  |  |  |  |  |  |  |  |  | 113.1 | 532 | 22.1 | 0.027 | 0.601 | 1.889 | 1489 | 947.9 | 0.001 | 13.79 |  |  |
| f ~ 584 | 24.2 | 32.8 | 31.4 | 7.24 | 0.11 | 12.12 | 584 | 1.409 | 738 | 151.4 | 730 | 29.6 | 0.027 | 0.704 | 2.212 | 1489 | 947.9 | 4E-04 | 18.92 | 2.6582 | 159.6 |
| L = 73 cm | 24.3 | 32.9 | 31.6 | 7.26 | 0.11 | 11.97 | 584 | 1.405 | 734 | 149.2 | 726 | 29.1 | 0.027 | 0.702 | 2.206 | 1489 | 947.9 | 4E-04 | 18.82 | 2.6506 | 159.6 |
| PR ~ 2.7 | 24.3 | 33.5 | 32.1 | 7.82 | 0.11 | 12.31 | 584 | 1.408 | 737 | 142.4 | 729 | 27.8 | 0.027 | 0.704 | 2.211 | 1489 | 947.9 | 4E-04 | 18.9 | 2.6563 | 159.6 |
|  |  |  |  |  |  |  |  |  |  | 147.7 | 729 | 28.9 | 0.027 | 0.703 | 2.21 | 1489 | 947.9 | 4E-04 | 18.88 |  |  |
|  | 24.4 | 36.7 | 34.8 | 10.4 | 0.13 | 14.34 | 585 | 1.41 | 739 | 147.4 | 732 | 28.8 | 0.027 | 0.704 | 2.211 | 1491 | 949.5 | 5E-04 | 18.96 | 2.6601 | 159.6 |
|  | 24.5 | 36.3 | 34.6 | 10.1 | 0.12 | 13.94 | 585 | 1.409 | 738 | 136.3 | 731 | 26.6 | 0.027 | 0.703 | 2.21 | 1491 | 949.5 | 5E-04 | 18.93 | 2.6582 | 159.6 |
|  | 24.7 | 36.8 | 34.9 | 10.2 | 0.13 | 14.17 | 585 | 1.409 | 738 | 148.2 | 731 | 29 | 0.027 | 0.704 | 2.21 | 1491 | 949.5 | 5E-04 | 18.93 | 2.6582 | 159.6 |
|  |  |  |  |  |  |  |  |  |  | 143.9 | 731 | 28.1 | 0.027 | 0.704 | 2.21 | 1491 | 949.5 | 5E-04 | 18.94 |  |  |
|  | 25 | 39.9 | 37.6 | 12.6 | 0.14 | 15.86 | 585 | 1.408 | 738 | 144.5 | 730 | 28.2 | 0.027 | 0.703 | 2.21 | 1491 | 949.5 | 6E-04 | 18.91 | 2.6563 | 159.6 |
|  | 25.1 | 40.3 | 38 | 12.9 | 0.14 | 16.13 | 585 | 1.407 | 737 | 144 | 729 | 28.1 | 0.027 | 0.703 | 2.209 | 1491 | 949.5 | 6E-04 | 18.89 | 2.6544 | 159.6 |
|  | 25.2 | 40.1 | 37.8 | 12.6 | 0.14 | 16 | 585 | 1.408 | 738 | 146 | 730 | 28.5 | 0.027 | 0.704 | 2.211 | 1491 | 949.5 | 6E-04 | 18.91 | 2.6563 | 159.6 |
|  |  |  |  |  |  |  |  |  |  | 144.8 | 730 | 28.3 | 0.027 | 0.703 | 2.21 | 1491 | 949.5 | 6E-04 | 18.9 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 584 | 0.1803 | 14.517 | 7.9764 | 7.9764 | 1.0532 | 18.416 | 0.1684 | 0.6561 | 0.002 | 0.6773 |
| L = 73 cm | 0.1747 | 13.024 | 7.0105 | 7.0105 | 1.0983 | 16.406 | 0.1684 | 0.6561 | 0.002 | 0.6773 |
| PR ~ 1.9 | 0.1734 | 12.997 | 6.8253 | 6.8253 | 1.0771 | 16.226 | 0.1683 | 0.6561 | 0.002 | 0.6773 |
| | | | | | | 17.016 | | | | 0.6773 |
| | 0.1547 | 11.656 | 4.8266 | 4.8266 | 0.9938 | 13.545 | 0.1682 | 0.6567 | 0.002 | 0.6779 |
| | 0.1536 | 11.66 | 4.7865 | 4.7865 | 0.997 | 13.52 | 0.1682 | 0.6561 | 0.002 | 0.6773 |
| | 0.1518 | 11.65 | 4.6617 | 4.6617 | 0.9881 | 13.423 | 0.1681 | 0.6554 | 0.002 | 0.6766 |
| | | | | | | 13.496 | | | | 0.6773 |
| | 0.142 | 9.8905 | 3.7573 | 3.7573 | 1.0802 | 11.28 | 0.1681 | 0.6554 | 0.002 | 0.6766 |
| | 0.1393 | 9.8788 | 3.6076 | 3.6076 | 1.0682 | 11.171 | 0.168 | 0.6574 | 0.002 | 0.6785 |
| | 0.1378 | 9.869 | 3.5133 | 3.5133 | 1.0581 | 11.101 | 0.168 | 0.6535 | 0.002 | 0.6747 |
| | | | | | | 11.184 | | | | 0.6766 |
| f ~ 584 | 0.1695 | 13.168 | 7.2696 | 7.2696 | 1.2099 | 16.75 | 0.1685 | 0.5491 | 0.002 | 0.5744 |
| L = 73 cm | 0.1665 | 13.145 | 6.9881 | 6.9881 | 1.1919 | 16.489 | 0.1685 | 0.5491 | 0.002 | 0.5744 |
| PR ~ 2.3 | 0.1658 | 12.021 | 6.7344 | 6.7344 | 1.3073 | 15.393 | 0.1684 | 0.55 | 0.002 | 0.5752 |
| | | | | | | 16.211 | | | | 0.5746 |
| | 0.1473 | 10.873 | 4.7632 | 4.7632 | 1.206 | 12.848 | 0.1683 | 0.5486 | 0.002 | 0.5739 |
| | 0.1457 | 10.874 | 4.6849 | 4.6849 | 1.2071 | 12.791 | 0.1682 | 0.5491 | 0.002 | 0.5743 |
| | 0.1465 | 10.859 | 4.6785 | 4.6785 | 1.1931 | 12.772 | 0.1682 | 0.5482 | 0.002 | 0.5734 |
| | | | | | | 12.804 | | | | 0.5738 |
| | 0.1358 | 9.3507 | 3.6819 | 3.6819 | 1.2762 | 10.779 | 0.168 | 0.5482 | 0.002 | 0.5733 |
| | 0.1348 | 9.3408 | 3.6082 | 3.6082 | 1.2653 | 10.72 | 0.1679 | 0.5486 | 0.002 | 0.5738 |
| | 0.1338 | 9.3305 | 3.537 | 3.537 | 1.2539 | 10.662 | 0.1679 | 0.5495 | 0.002 | 0.5746 |
| | | | | | | 10.72 | | | | 0.5739 |
| f ~ 584 | 0.1574 | 11.391 | 6.9051 | 6.9051 | 1.6939 | 15.1 | 0.1682 | 0.4684 | 0.002 | 0.4977 |
| L = 73 cm | 0.1582 | 11.365 | 6.8891 | 6.8891 | 1.6691 | 15.063 | 0.1681 | 0.4698 | 0.002 | 0.4989 |
| PR ~ 2.7 | 0.1544 | 11.284 | 6.3941 | 6.3941 | 1.5931 | 14.548 | 0.1681 | 0.4688 | 0.002 | 0.498 |
| | | | | | | 14.904 | | | | 0.4982 |
| | 0.1416 | 9.6893 | 4.8078 | 4.8078 | 1.6491 | 11.952 | 0.168 | 0.4681 | 0.002 | 0.4973 |
| | 0.1423 | 10.325 | 4.953 | 4.953 | 1.5245 | 12.571 | 0.168 | 0.4684 | 0.002 | 0.4976 |
| | 0.1427 | 9.6972 | 4.8913 | 4.8913 | 1.6579 | 12.027 | 0.1679 | 0.4684 | 0.002 | 0.4976 |
| | | | | | | 12.183 | | | | 0.4975 |
| | 0.1333 | 9.0118 | 3.9568 | 3.9568 | 1.6165 | 10.731 | 0.1677 | 0.4688 | 0.002 | 0.4978 |
| | 0.132 | 9.0069 | 3.8766 | 3.8766 | 1.6107 | 10.667 | 0.1676 | 0.4691 | 0.002 | 0.4981 |
| | 0.1329 | 9.0261 | 3.963 | 3.963 | 1.6334 | 10.75 | 0.1676 | 0.4688 | 0.002 | 0.4978 |
| | | | | | | 10.716 | | | | 0.4979 |

| Experiment Information | Ta (C) | T tc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | $\frac{Gr}{Rs*Rs}$ | $\frac{Rs}{\Lambda}$ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1055 | 22.8 | 30.7 | 30.2 | 7.38 | 0.07 | 7.31 | 1055 | 0.702 | 101 | 57.03 | 99.9 | 11.1 | 0.049 | 0.194 | 0.609 | 2690 | 1712 | 0.021 | 1.926 | 1.3244 | 153.5 |
| L = 73 cm | 23.1 | 31.1 | 30.6 | 7.47 | 0.07 | 7.49 | 1055 | 0.702 | 101 | 57.75 | 99.8 | 11.3 | 0.049 | 0.194 | 0.609 | 2690 | 1712 | 0.021 | 1.925 | 1.3244 | 153.5 |
| PR ~ 1.3 | 23 | 31.4 | 30.8 | 7.85 | 0.07 | 7.73 | 1056 | 0.706 | 102 | 56.69 | 101 | 11.1 | 0.049 | 0.195 | 0.612 | 2692 | 1714 | 0.021 | 1.95 | 1.3319 | 153.6 |
| | | | | | | | | | | 57.16 | 100 | 11.2 | 0.049 | 0.194 | 0.61 | 2691 | 1713 | 0.021 | 1.933 | | |
| | 23.1 | 35.1 | 34.3 | 11.2 | 0.08 | 9.3 | 1056 | 0.707 | 102 | 54.42 | 101 | 10.6 | 0.049 | 0.195 | 0.613 | 2692 | 1714 | 0.03 | 1.955 | 1.3338 | 153.6 |
| | 23.2 | 35.6 | 34.7 | 11.5 | 0.09 | 9.45 | 1056 | 0.709 | 103 | 60.64 | 102 | 11.8 | 0.049 | 0.196 | 0.615 | 2692 | 1714 | 0.03 | 1.966 | 1.3376 | 153.6 |
| | 23.3 | 36 | 35.1 | 11.8 | 0.09 | 9.53 | 1056 | 0.708 | 103 | 59.64 | 102 | 11.7 | 0.049 | 0.195 | 0.614 | 2692 | 1714 | 0.031 | 1.96 | 1.3357 | 153.6 |
| | | | | | | | | | | 58.23 | 102 | 11.4 | 0.049 | 0.195 | 0.614 | 2692 | 1714 | 0.031 | 1.96 | | |
| | 23.6 | 40.9 | 39.7 | 16.1 | 0.1 | 11.48 | 1056 | 0.708 | 103 | 58.53 | 102 | 11.4 | 0.049 | 0.195 | 0.614 | 2692 | 1714 | 0.042 | 1.959 | 1.3357 | 153.6 |
| | 23.7 | 40.6 | 39.5 | 15.8 | 0.1 | 11.09 | 1056 | 0.707 | 103 | 57.83 | 101 | 11.3 | 0.049 | 0.195 | 0.613 | 2692 | 1714 | 0.041 | 1.953 | 1.3338 | 153.6 |
| | 23.8 | 40.7 | 39.6 | 15.8 | 0.1 | 11.21 | 1056 | 0.705 | 102 | 58.5 | 101 | 11.4 | 0.049 | 0.195 | 0.612 | 2692 | 1714 | 0.041 | 1.941 | 1.33 | 153.6 |
| | | | | | | | | | | 58.28 | 101 | 11.4 | 0.049 | 0.195 | 0.613 | 2692 | 1714 | 0.042 | 1.951 | | |
| f ~ 1055 | 23.7 | 31.8 | 31.3 | 7.57 | 0.07 | 7.47 | 1056 | 0.801 | 132 | 56.82 | 130 | 11.1 | 0.049 | 0.221 | 0.695 | 2692 | 1714 | 0.012 | 2.507 | 1.5111 | 154.7 |
| L = 73 cm | 23.4 | 31.7 | 31.1 | 7.75 | 0.07 | 7.74 | 1056 | 0.803 | 132 | 57.5 | 131 | 11.2 | 0.049 | 0.222 | 0.696 | 2692 | 1714 | 0.012 | 2.521 | 1.5149 | 154.7 |
| PR ~ 1.5 | 23.5 | 31.9 | 31.3 | 7.84 | 0.07 | 7.87 | 1056 | 0.803 | 132 | 57.79 | 131 | 11.3 | 0.049 | 0.222 | 0.696 | 2692 | 1714 | 0.012 | 2.52 | 1.5149 | 154.7 |
| | | | | | | | | | | 57.37 | 131 | 11.2 | 0.049 | 0.222 | 0.696 | 2692 | 1714 | 0.012 | 2.516 | | |
| | 23.7 | 36.4 | 35.5 | 11.8 | 0.09 | 9.95 | 1056 | 0.8 | 131 | 62.47 | 130 | 12.2 | 0.049 | 0.221 | 0.694 | 2692 | 1714 | 0.019 | 2.5 | 1.5093 | 154.7 |
| | 23.7 | 36.3 | 35.4 | 11.7 | 0.09 | 9.7 | 1056 | 0.799 | 131 | 61.3 | 129 | 12 | 0.049 | 0.221 | 0.693 | 2692 | 1714 | 0.019 | 2.494 | 1.5074 | 154.7 |
| | 23.7 | 36.1 | 35.2 | 11.5 | 0.09 | 9.49 | 1057 | 0.799 | 131 | 60.92 | 130 | 11.9 | 0.049 | 0.22 | 0.693 | 2695 | 1716 | 0.018 | 2.498 | 1.5074 | 154.7 |
| | | | | | | | | | | 61.56 | 130 | 12 | 0.049 | 0.221 | 0.693 | 2693 | 1714 | 0.019 | 2.497 | | |
| | 24 | 39.7 | 38.6 | 14.6 | 0.1 | 10.91 | 1057 | 0.802 | 132 | 61.5 | 131 | 12 | 0.049 | 0.221 | 0.695 | 2695 | 1716 | 0.023 | 2.515 | 1.513 | 154.7 |
| | 24 | 40.4 | 39.3 | 15.3 | 0.1 | 11.28 | 1057 | 0.804 | 133 | 60.82 | 131 | 11.9 | 0.049 | 0.222 | 0.697 | 2695 | 1716 | 0.023 | 2.528 | 1.5168 | 154.7 |
| | 24 | 40.1 | 39 | 15 | 0.1 | 11.15 | 1057 | 0.803 | 132 | 61.27 | 131 | 12 | 0.049 | 0.222 | 0.696 | 2695 | 1716 | 0.023 | 2.522 | 1.5149 | 154.7 |
| | | | | | | | | | | 61.2 | 131 | 12 | 0.049 | 0.222 | 0.696 | 2695 | 1716 | 0.023 | 2.522 | | |
| f ~ 1055 | 23.9 | 32.7 | 32 | 8.13 | 0.08 | 8.22 | 1057 | 0.902 | 167 | 66.52 | 165 | 13 | 0.049 | 0.249 | 0.782 | 2695 | 1716 | 0.008 | 3.182 | 1.7017 | 155.7 |
| L = 73 cm | 23.8 | 31.8 | 31.3 | 7.45 | 0.07 | 7.7 | 1057 | 0.903 | 167 | 59.49 | 166 | 11.6 | 0.049 | 0.249 | 0.783 | 2695 | 1716 | 0.007 | 3.19 | 1.7036 | 155.7 |
| PR ~ 1.7 | 23.8 | 32 | 31.4 | 7.64 | 0.07 | 7.88 | 1057 | 0.903 | 167 | 59.39 | 166 | 11.6 | 0.049 | 0.249 | 0.783 | 2695 | 1716 | 0.007 | 3.19 | 1.7036 | 155.7 |
| | | | | | | | | | | 61.8 | 165 | 12.1 | 0.049 | 0.249 | 0.783 | 2695 | 1716 | 0.008 | 3.187 | | |
| | 24 | 35.8 | 34.9 | 10.9 | 0.09 | 9.4 | 1057 | 0.901 | 167 | 63.6 | 165 | 12.4 | 0.049 | 0.249 | 0.781 | 2695 | 1716 | 0.011 | 3.175 | 1.6998 | 155.7 |
| | 24.1 | 36 | 35.1 | 11 | 0.09 | 9.69 | 1057 | 0.901 | 167 | 65.13 | 165 | 12.7 | 0.049 | 0.249 | 0.781 | 2695 | 1716 | 0.011 | 3.174 | 1.6998 | 155.7 |
| | 24.1 | 36.5 | 35.6 | 11.5 | 0.09 | 9.96 | 1057 | 0.901 | 167 | 64.17 | 165 | 12.5 | 0.049 | 0.249 | 0.781 | 2695 | 1716 | 0.011 | 3.174 | 1.6998 | 155.7 |
| | | | | | | | | | | 64.3 | 165 | 12.6 | 0.049 | 0.249 | 0.781 | 2695 | 1716 | 0.011 | 3.174 | | |
| | 24.4 | 41.5 | 40.2 | 15.8 | 0.11 | 11.8 | 1057 | 0.9 | 167 | 67.65 | 164 | 13.2 | 0.049 | 0.249 | 0.781 | 2695 | 1716 | 0.015 | 3.165 | 1.6979 | 155.7 |
| | 24.5 | 40.2 | 39.1 | 14.6 | 0.1 | 11.16 | 1058 | 0.903 | 168 | 63.02 | 166 | 12.3 | 0.049 | 0.249 | 0.783 | 2697 | 1717 | 0.014 | 3.191 | 1.7036 | 155.7 |
| | 24.5 | 40.6 | 39.4 | 14.9 | 0.1 | 11.44 | 1058 | 0.902 | 167 | 62.99 | 165 | 12.3 | 0.049 | 0.249 | 0.782 | 2697 | 1717 | 0.014 | 3.184 | 1.7017 | 155.7 |
| | | | | | | | | | | 64.55 | 165 | 12.6 | 0.049 | 0.249 | 0.782 | 2696 | 1717 | 0.014 | 3.18 | | |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1055 | 0.2 | 15.831 | 6.7765 | 6.7765 | 0.638 | 18.518 | 0.1689 | 0.9402 | 0.002 | 0.9552 |
| L = 73 cm | 0.1966 | 15.844 | 6.6974 | 6.6974 | 0.6461 | 18.472 | 0.1688 | 0.9402 | 0.002 | 0.9552 |
| PR ~ 1.3 | 0.192 | 15.825 | 6.3707 | 6.3707 | 0.6343 | 18.222 | 0.1688 | 0.9348 | 0.002 | 0.95 |
| | | | | | | 18.404 | | | | 0.9535 |
| | 0.1682 | 13.877 | 4.4478 | 4.4478 | 0.6089 | 15.249 | 0.1688 | 0.9335 | 0.002 | 0.9487 |
| | 0.1675 | 12.484 | 4.3354 | 4.3354 | 0.6785 | 13.926 | 0.1687 | 0.9309 | 0.002 | 0.9461 |
| | 0.1664 | 12.47 | 4.2281 | 4.2281 | 0.6673 | 13.846 | 0.1687 | 0.9322 | 0.002 | 0.9473 |
| | | | | | | 14.34 | | | | 0.9474 |
| | 0.1471 | 11.262 | 3.0999 | 3.0999 | 0.6548 | 12.104 | 0.1685 | 0.9322 | 0.002 | 0.9473 |
| | 0.1502 | 11.253 | 3.1707 | 3.1707 | 0.647 | 12.131 | 0.1684 | 0.9335 | 0.002 | 0.9486 |
| | 0.1493 | 11.261 | 3.1731 | 3.1731 | 0.6545 | 12.141 | 0.1684 | 0.9362 | 0.002 | 0.9512 |
| | | | | | | 12.125 | | | | 0.949 |
| f ~ 1055 | 0.1968 | 15.827 | 6.6077 | 6.6077 | 0.6357 | 18.392 | 0.1684 | 0.824 | 0.002 | 0.841 |
| L = 73 cm | 0.192 | 15.84 | 6.4535 | 6.4535 | 0.6434 | 18.293 | 0.1686 | 0.8219 | 0.002 | 0.839 |
| PR ~ 1.5 | 0.1898 | 15.845 | 6.3788 | 6.3788 | 0.6466 | 18.245 | 0.1685 | 0.8219 | 0.002 | 0.839 |
| | | | | | | 18.31 | | | | 0.8397 |
| | 0.1622 | 12.51 | 4.2419 | 4.2419 | 0.6989 | 13.893 | 0.1684 | 0.825 | 0.002 | 0.842 |
| | 0.1647 | 12.493 | 4.2698 | 4.2698 | 0.6859 | 13.894 | 0.1684 | 0.826 | 0.002 | 0.843 |
| | 0.1671 | 12.488 | 4.3368 | 4.3368 | 0.6815 | 13.93 | 0.1684 | 0.826 | 0.002 | 0.843 |
| | | | | | | 13.906 | | | | 0.8427 |
| | 0.1525 | 11.3 | 3.4275 | 3.4275 | 0.6881 | 12.316 | 0.1683 | 0.8229 | 0.002 | 0.84 |
| | 0.1491 | 11.292 | 3.2787 | 3.2787 | 0.6805 | 12.226 | 0.1683 | 0.8209 | 0.002 | 0.838 |
| | 0.1503 | 11.298 | 3.3415 | 3.3415 | 0.6855 | 12.266 | 0.1683 | 0.8219 | 0.002 | 0.839 |
| | | | | | | 12.27 | | | | 0.839 |
| f ~ 1055 | 0.1858 | 14.072 | 6.1503 | 6.1503 | 0.7442 | 16.561 | 0.1683 | 0.7317 | 0.002 | 0.7508 |
| L = 73 cm | 0.1931 | 15.876 | 6.7109 | 6.7109 | 0.6656 | 18.51 | 0.1684 | 0.7309 | 0.002 | 0.75 |
| PR ~ 1.7 | 0.1899 | 15.874 | 6.5465 | 6.5465 | 0.6644 | 18.39 | 0.1684 | 0.7309 | 0.002 | 0.75 |
| | | | | | | 17.82 | | | | 0.7503 |
| | 0.1687 | 12.527 | 4.5714 | 4.5714 | 0.7116 | 14.115 | 0.1683 | 0.7325 | 0.002 | 0.7516 |
| | 0.1656 | 12.549 | 4.5409 | 4.5409 | 0.7287 | 14.116 | 0.1682 | 0.7325 | 0.002 | 0.7516 |
| | 0.1624 | 12.535 | 4.353 | 4.353 | 0.718 | 13.984 | 0.1682 | 0.7325 | 0.002 | 0.7516 |
| | | | | | | 14.072 | | | | 0.7516 |
| | 0.146 | 10.395 | 3.1692 | 3.1692 | 0.7569 | 11.347 | 0.168 | 0.7333 | 0.002 | 0.7523 |
| | 0.1505 | 11.32 | 3.4335 | 3.4335 | 0.705 | 12.339 | 0.168 | 0.7309 | 0.002 | 0.75 |
| | 0.1481 | 11.32 | 3.3481 | 3.3481 | 0.7048 | 12.291 | 0.168 | 0.7317 | 0.002 | 0.7507 |
| | | | | | | 11.992 | | | | 0.751 |

| Experiment Information | Ta (C) | T to (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mid V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1055 | 24.3 | 32 | 31.5 | 7.16 | 0.07 | 7.61 | 1058 | 1 | 205 | 61.2 | 203 | 12 | 0.049 | 0.276 | 0.867 | 2697 | 1717 | 0.005 | 3.914 | 1.8866 | 156.6 |
| L = 73 cm | 24.3 | 32.3 | 31.7 | 7.45 | 0.07 | 7.73 | 1058 | 1 | 205 | 59.74 | 203 | 11.7 | 0.049 | 0.276 | 0.867 | 2697 | 1717 | 0.005 | 3.914 | 1.8866 | 156.6 |
| PR ~ 1.9 | 24.4 | 32.6 | 32 | 7.63 | 0.07 | 7.95 | 1058 | 1.002 | 206 | 59.95 | 204 | 11.7 | 0.049 | 0.277 | 0.869 | 2697 | 1717 | 0.005 | 3.929 | 1.8904 | 156.6 |
|  |  |  |  |  |  |  |  |  |  | 60.3 | 204 | 11.8 | 0.049 | 0.276 | 0.867 | 2697 | 1717 | 0.005 | 3.919 |  |  |
|  | 24.6 | 36.3 | 35.4 | 10.8 | 0.09 | 9.58 | 1058 | 0.999 | 205 | 65.52 | 203 | 12.8 | 0.049 | 0.276 | 0.866 | 2697 | 1717 | 0.007 | 3.904 | 1.8847 | 156.6 |
|  | 24.8 | 35.5 | 34.8 | 9.95 | 0.08 | 9.14 | 1058 | 0.997 | 204 | 60.4 | 202 | 11.8 | 0.049 | 0.275 | 0.865 | 2697 | 1717 | 0.006 | 3.887 | 1.8809 | 156.6 |
|  | 24.8 | 36.5 | 35.6 | 10.8 | 0.09 | 9.62 | 1058 | 0.996 | 204 | 65.81 | 201 | 12.9 | 0.049 | 0.275 | 0.864 | 2697 | 1717 | 0.007 | 3.88 | 1.879 | 156.6 |
|  |  |  |  |  |  |  |  |  |  | 63.91 | 202 | 12.5 | 0.049 | 0.275 | 0.865 | 2697 | 1717 | 0.007 | 3.89 |  |  |
|  | 24.9 | 39.8 | 38.7 | 13.8 | 0.1 | 11.16 | 1059 | 0.996 | 204 | 66.68 | 202 | 13 | 0.049 | 0.275 | 0.863 | 2700 | 1719 | 0.009 | 3.884 | 1.879 | 156.6 |
|  | 24.9 | 40.6 | 39.4 | 14.5 | 0.1 | 11.49 | 1059 | 0.998 | 205 | 65.03 | 203 | 12.7 | 0.049 | 0.275 | 0.865 | 2700 | 1719 | 0.009 | 3.9 | 1.8828 | 156.6 |
|  | 25 | 40.5 | 39.4 | 14.4 | 0.1 | 11.24 | 1059 | 0.997 | 204 | 64.39 | 202 | 12.6 | 0.049 | 0.275 | 0.864 | 2700 | 1719 | 0.009 | 3.892 | 1.8809 | 156.6 |
|  |  |  |  |  |  |  |  |  |  | 65.37 | 202 | 12.8 | 0.049 | 0.275 | 0.864 | 2700 | 1719 | 0.009 | 3.892 |  |  |
| f ~ 1055 | 22.1 | 29.8 | 29.1 | 7.03 | 0.08 | 8.21 | 1055 | 1.112 | 253 | 76.82 | 251 | 15 | 0.049 | 0.307 | 0.963 | 2690 | 1712 | 0.003 | 4.836 | 2.0979 | 157.5 |
| L = 73 cm | 22.2 | 30.5 | 29.8 | 7.61 | 0.08 | 8.47 | 1055 | 1.104 | 249 | 73.23 | 247 | 14.3 | 0.049 | 0.304 | 0.956 | 2690 | 1712 | 0.004 | 4.766 | 2.0828 | 157.5 |
| PR ~ 2.1 | 22.3 | 30.3 | 29.6 | 7.32 | 0.08 | 8.29 | 1055 | 1.104 | 249 | 74.46 | 247 | 14.5 | 0.049 | 0.304 | 0.956 | 2690 | 1712 | 0.003 | 4.766 | 2.0828 | 157.5 |
|  |  |  |  |  |  |  |  |  |  | 74.84 | 248 | 14.6 | 0.049 | 0.305 | 0.959 | 2690 | 1712 | 0.003 | 4.789 |  |  |
|  | 22.4 | 34.3 | 33.4 | 11 | 0.09 | 10.33 | 1055 | 1.102 | 248 | 69.8 | 246 | 13.6 | 0.049 | 0.304 | 0.955 | 2690 | 1712 | 0.005 | 4.748 | 2.079 | 157.4 |
|  | 22.6 | 35.3 | 34.2 | 11.6 | 0.1 | 10.6 | 1055 | 1.101 | 248 | 75.02 | 246 | 14.7 | 0.049 | 0.304 | 0.954 | 2690 | 1712 | 0.005 | 4.738 | 2.0771 | 157.4 |
|  | 22.8 | 35 | 33.9 | 11.1 | 0.1 | 10.39 | 1055 | 1.098 | 247 | 76.69 | 244 | 15 | 0.049 | 0.303 | 0.952 | 2690 | 1712 | 0.005 | 4.711 | 2.0715 | 157.4 |
|  |  |  |  |  |  |  |  |  |  | 73.84 | 245 | 14.4 | 0.049 | 0.304 | 0.954 | 2690 | 1712 | 0.005 | 4.732 |  |  |
|  | 23 | 39.9 | 38.5 | 15.5 | 0.11 | 12.45 | 1056 | 1.102 | 249 | 72.64 | 246 | 14.2 | 0.049 | 0.304 | 0.955 | 2692 | 1714 | 0.007 | 4.75 | 2.079 | 157.4 |
|  | 23.1 | 39.4 | 38 | 14.9 | 0.11 | 12.19 | 1056 | 1.103 | 249 | 73.84 | 247 | 14.4 | 0.049 | 0.304 | 0.956 | 2692 | 1714 | 0.007 | 4.758 | 2.0809 | 157.5 |
|  | 23.1 | 39.7 | 38.3 | 15.2 | 0.11 | 12.39 | 1056 | 1.103 | 249 | 73.68 | 247 | 14.4 | 0.049 | 0.304 | 0.956 | 2692 | 1714 | 0.007 | 4.758 | 2.0809 | 157.5 |
|  |  |  |  |  |  |  |  |  |  | 73.38 | 247 | 14.3 | 0.049 | 0.304 | 0.956 | 2692 | 1714 | 0.007 | 4.755 |  |  |
| f ~ 1055 | 23.1 | 31.1 | 30.4 | 7.32 | 0.08 | 8.35 | 1056 | 1.203 | 297 | 75.05 | 294 | 14.7 | 0.049 | 0.332 | 1.043 | 2692 | 1714 | 0.002 | 5.66 | 2.2696 | 158.2 |
| L = 73 cm | 23.1 | 31.3 | 30.6 | 7.5 | 0.08 | 8.54 | 1056 | 1.203 | 297 | 74.87 | 294 | 14.6 | 0.049 | 0.332 | 1.043 | 2692 | 1714 | 0.002 | 5.66 | 2.2696 | 158.2 |
| PR ~ 2.3 | 23.1 | 31.5 | 30.8 | 7.69 | 0.08 | 8.76 | 1056 | 1.205 | 298 | 74.98 | 295 | 14.6 | 0.049 | 0.332 | 1.044 | 2692 | 1714 | 0.002 | 5.679 | 2.2733 | 158.2 |
|  |  |  |  |  |  |  |  |  |  | 74.97 | 294 | 14.6 | 0.049 | 0.332 | 1.043 | 2692 | 1714 | 0.002 | 5.666 |  |  |
|  | 23.3 | 35.2 | 34.1 | 10.8 | 0.1 | 10.6 | 1056 | 1.202 | 296 | 80.56 | 293 | 15.7 | 0.049 | 0.332 | 1.042 | 2692 | 1714 | 0.003 | 5.649 | 2.2677 | 158.2 |
|  | 23.4 | 35.6 | 34.5 | 11.1 | 0.1 | 10.8 | 1056 | 1.204 | 297 | 80.01 | 294 | 15.6 | 0.049 | 0.332 | 1.044 | 2692 | 1714 | 0.003 | 5.667 | 2.2714 | 158.2 |
|  | 23.4 | 36 | 34.9 | 11.5 | 0.1 | 11.03 | 1056 | 1.2 | 295 | 79.04 | 292 | 15.4 | 0.049 | 0.331 | 1.041 | 2692 | 1714 | 0.004 | 5.629 | 2.2639 | 158.2 |
|  |  |  |  |  |  |  |  |  |  | 79.87 | 293 | 15.6 | 0.049 | 0.332 | 1.042 | 2692 | 1714 | 0.004 | 5.648 |  |  |
|  | 23.6 | 40 | 38.4 | 14.8 | 0.12 | 12.77 | 1057 | 1.197 | 294 | 84.92 | 291 | 16.6 | 0.049 | 0.33 | 1.037 | 2695 | 1716 | 0.005 | 5.606 | 2.2582 | 158.2 |
|  | 23.7 | 39.9 | 38.5 | 14.8 | 0.11 | 12.67 | 1057 | 1.199 | 295 | 77.54 | 292 | 15.2 | 0.049 | 0.331 | 1.039 | 2695 | 1716 | 0.005 | 5.624 | 2.262 | 158.2 |
|  | 23.8 | 40.5 | 38.9 | 15.1 | 0.12 | 13 | 1057 | 1.2 | 295 | 84.9 | 292 | 16.6 | 0.049 | 0.331 | 1.04 | 2695 | 1716 | 0.005 | 5.633 | 2.2639 | 158.2 |
|  |  |  |  |  |  |  |  |  |  | 82.46 | 292 | 16.1 | 0.049 | 0.331 | 1.039 | 2695 | 1716 | 0.005 | 5.621 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1055 | 0.1952 | 15.908 | 6.9862 | 6.9862 | 0.6848 | 18.74 | 0.1681 | 0.66 | 0.002 | 0.6811 |
| L = 73 cm | 0.1926 | 15.881 | 6.7128 | 6.7128 | 0.6683 | 18.515 | 0.1681 | 0.66 | 0.002 | 0.6811 |
| PR ~ 1.9 | 0.1889 | 15.885 | 6.5507 | 6.5507 | 0.6708 | 18.402 | 0.168 | 0.6587 | 0.002 | 0.6798 |
| | | | | | | 18.552 | | | | 0.6806 |
| | 0.1669 | 12.554 | 4.6206 | 4.6206 | 0.733 | 14.173 | 0.1679 | 0.6607 | 0.002 | 0.6817 |
| | 0.1713 | 13.973 | 5.0228 | 5.0228 | 0.6758 | 15.691 | 0.1678 | 0.662 | 0.002 | 0.6829 |
| | 0.1665 | 12.558 | 4.6222 | 4.6222 | 0.7363 | 14.178 | 0.1678 | 0.6627 | 0.002 | 0.6836 |
| | | | | | | 14.681 | | | | 0.6827 |
| | 0.1511 | 11.368 | 3.6331 | 3.6331 | 0.746 | 12.498 | 0.1678 | 0.6627 | 0.002 | 0.6836 |
| | 0.1481 | 11.346 | 3.4415 | 3.4415 | 0.7276 | 12.369 | 0.1678 | 0.6613 | 0.002 | 0.6823 |
| | 0.1501 | 11.338 | 3.4833 | 3.4833 | 0.7204 | 12.384 | 0.1677 | 0.662 | 0.002 | 0.6829 |
| | | | | | | 12.417 | | | | 0.6829 |
| f ~ 1055 | 0.1882 | 14.238 | 7.1119 | 7.1119 | 0.8595 | 17.454 | 0.1693 | 0.5935 | 0.002 | 0.6172 |
| L = 73 cm | 0.1833 | 14.18 | 6.5709 | 6.5709 | 0.8193 | 16.974 | 0.1693 | 0.5978 | 0.002 | 0.6213 |
| PR ~ 2.1 | 0.1864 | 14.2 | 6.8269 | 6.8269 | 0.8331 | 17.192 | 0.1692 | 0.5978 | 0.002 | 0.6213 |
| | | | | | | 17.207 | | | | 0.62 |
| | 0.1595 | 12.616 | 4.5653 | 4.5653 | 0.781 | 14.194 | 0.1692 | 0.5989 | 0.002 | 0.6223 |
| | 0.1578 | 11.476 | 4.3031 | 4.3031 | 0.8393 | 13.018 | 0.1691 | 0.5995 | 0.002 | 0.6228 |
| | 0.1601 | 11.498 | 4.488 | 4.488 | 0.858 | 13.163 | 0.1689 | 0.6011 | 0.002 | 0.6244 |
| | | | | | | 13.458 | | | | 0.6232 |
| | 0.1421 | 10.455 | 3.225 | 3.225 | 0.8127 | 11.436 | 0.1688 | 0.5989 | 0.002 | 0.6223 |
| | 0.1441 | 10.469 | 3.3483 | 3.3483 | 0.8261 | 11.52 | 0.1688 | 0.5984 | 0.002 | 0.6217 |
| | 0.1426 | 10.467 | 3.2872 | 3.2872 | 0.8243 | 11.483 | 0.1688 | 0.5984 | 0.002 | 0.6217 |
| | | | | | | 11.48 | | | | 0.6219 |
| f ~ 1055 | 0.1856 | 14.209 | 6.8315 | 6.8315 | 0.8397 | 17.204 | 0.1688 | 0.5486 | 0.002 | 0.574 |
| L = 73 cm | 0.1826 | 14.207 | 6.6635 | 6.6635 | 0.8377 | 17.069 | 0.1688 | 0.5486 | 0.002 | 0.574 |
| PR ~ 2.3 | 0.1794 | 14.208 | 6.5057 | 6.5057 | 0.8389 | 16.949 | 0.1688 | 0.5477 | 0.002 | 0.5731 |
| | | | | | | 17.074 | | | | 0.5737 |
| | 0.1588 | 11.549 | 4.6213 | 4.6213 | 0.9013 | 13.301 | 0.1687 | 0.5491 | 0.002 | 0.5744 |
| | 0.1567 | 11.541 | 4.5049 | 4.5049 | 0.8952 | 13.214 | 0.1686 | 0.5482 | 0.002 | 0.5735 |
| | 0.1544 | 11.529 | 4.3571 | 4.3571 | 0.8843 | 13.103 | 0.1686 | 0.55 | 0.002 | 0.5753 |
| | | | | | | 13.206 | | | | 0.5744 |
| | 0.1418 | 9.7633 | 3.3697 | 3.3697 | 0.9501 | 10.907 | 0.1685 | 0.5514 | 0.002 | 0.5766 |
| | 0.1413 | 10.513 | 3.3831 | 3.3831 | 0.8676 | 11.584 | 0.1684 | 0.5505 | 0.002 | 0.5757 |
| | 0.1403 | 9.763 | 3.3091 | 3.3091 | 0.9498 | 10.869 | 0.1684 | 0.55 | 0.002 | 0.5752 |
| | | | | | | 11.12 | | | | 0.5758 |

| Experiment Information | T a (C) | T to (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs/Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1055 | 23.7 | 31.4 | 30.7 | 7 | 0.08 | 8.59 | 1057 | 1.301 | 347 | 80.73 | 344 | 15.8 | 0.049 | 0.359 | 1.128 | 2695 | 1716 | 0.002 | 6.622 | 2.4544 | 158.9 |
| L = 73 cm | 23.7 | 31.7 | 31 | 7.27 | 0.08 | 8.91 | 1057 | 1.302 | 348 | 80.59 | 344 | 15.7 | 0.049 | 0.359 | 1.128 | 2695 | 1716 | 0.002 | 6.632 | 2.4563 | 158.9 |
| PR ~ 2.5 | 23.7 | 32.4 | 31.5 | 7.84 | 0.09 | 9.37 | 1057 | 1.302 | 348 | 88.45 | 344 | 17.3 | 0.049 | 0.359 | 1.128 | 2695 | 1716 | 0.002 | 6.632 | 2.4563 | 158.9 |
|  |  |  |  |  |  |  |  |  |  | 83.25 | 344 | 16.3 | 0.049 | 0.359 | 1.128 | 2695 | 1716 | 0.002 | 6.629 |  |  |
|  | 23.9 | 35.8 | 34.7 | 10.8 | 0.1 | 10.96 | 1057 | 1.302 | 348 | 83.58 | 344 | 16.3 | 0.049 | 0.359 | 1.129 | 2695 | 1716 | 0.002 | 6.63 | 2.4563 | 158.9 |
|  | 23.9 | 36.5 | 35.3 | 11.4 | 0.1 | 11.41 | 1057 | 1.302 | 348 | 82.04 | 344 | 16 | 0.049 | 0.359 | 1.129 | 2695 | 1716 | 0.003 | 6.63 | 2.4563 | 158.9 |
|  | 23.9 | 36.2 | 35.1 | 11.2 | 0.1 | 11.18 | 1057 | 1.299 | 346 | 82.38 | 343 | 16.1 | 0.049 | 0.358 | 1.126 | 2695 | 1716 | 0.003 | 6.6 | 2.4507 | 158.9 |
|  |  |  |  |  |  |  |  |  |  | 82.66 | 344 | 16.2 | 0.049 | 0.359 | 1.128 | 2695 | 1716 | 0.003 | 6.62 |  |  |
|  | 24 | 40.1 | 38.5 | 14.5 | 0.12 | 13.12 | 1057 | 1.296 | 345 | 89.32 | 341 | 17.5 | 0.049 | 0.358 | 1.124 | 2695 | 1716 | 0.003 | 6.568 | 2.445 | 158.9 |
|  | 24 | 40.3 | 38.7 | 14.7 | 0.12 | 13.25 | 1057 | 1.296 | 345 | 89.07 | 341 | 17.4 | 0.049 | 0.358 | 1.124 | 2695 | 1716 | 0.003 | 6.568 | 2.445 | 158.9 |
|  | 24.1 | 40.7 | 39.1 | 15 | 0.12 | 13.46 | 1057 | 1.293 | 343 | 88.82 | 339 | 17.4 | 0.049 | 0.357 | 1.121 | 2695 | 1716 | 0.003 | 6.537 | 2.4393 | 158.8 |
|  |  |  |  |  |  |  |  |  |  | 89.07 | 340 | 17.4 | 0.049 | 0.357 | 1.123 | 2695 | 1716 | 0.003 | 6.558 |  |  |
| f ~ 585 | 23.4 | 31.3 | 30.4 | 6.97 | 0.09 | 10.09 | 587 | 1.102 | 448 | 107.1 | 447 | 20.9 | 0.027 | 0.547 | 1.719 | 1497 | 952.7 | 9E-04 | 11.55 | 2.079 | 157.4 |
| L = 73 cm | 23.6 | 32.3 | 31.2 | 7.62 | 0.1 | 10.64 | 587 | 1.101 | 448 | 114.9 | 446 | 22.4 | 0.027 | 0.547 | 1.718 | 1497 | 952.7 | 0.001 | 11.53 | 2.0771 | 157.4 |
| PR ~ 2.1 | 23.7 | 32.9 | 31.8 | 8.1 | 0.1 | 10.81 | 587 | 1.099 | 446 | 109.8 | 445 | 21.4 | 0.027 | 0.546 | 1.715 | 1497 | 952.7 | 0.001 | 11.49 | 2.0733 | 157.4 |
|  |  |  |  |  |  |  |  |  |  | 110.6 | 446 | 21.6 | 0.027 | 0.547 | 1.717 | 1497 | 952.7 | 0.001 | 11.52 |  |  |
|  | 23.8 | 36.3 | 34.9 | 11.1 | 0.11 | 12.56 | 587 | 1.099 | 446 | 102.4 | 445 | 20 | 0.027 | 0.546 | 1.715 | 1497 | 952.7 | 0.001 | 11.49 | 2.0733 | 157.4 |
|  | 23.8 | 37.1 | 35.5 | 11.7 | 0.12 | 12.93 | 587 | 1.099 | 446 | 108.9 | 445 | 21.3 | 0.027 | 0.546 | 1.715 | 1497 | 952.7 | 0.002 | 11.49 | 2.0733 | 157.4 |
|  | 24 | 36.1 | 34.7 | 10.7 | 0.11 | 12.15 | 588 | 1.099 | 446 | 102.4 | 445 | 20 | 0.027 | 0.545 | 1.713 | 1499 | 954.3 | 0.001 | 11.49 | 2.0733 | 157.4 |
|  |  |  |  |  |  |  |  |  |  | 104.6 | 445 | 20.4 | 0.027 | 0.546 | 1.715 | 1497 | 953.3 | 0.002 | 11.49 |  |  |
|  | 24.2 | 39.5 | 37.8 | 13.6 | 0.12 | 13.89 | 588 | 1.097 | 444 | 100.8 | 443 | 19.7 | 0.027 | 0.545 | 1.711 | 1499 | 954.3 | 0.002 | 11.45 | 2.0696 | 157.4 |
|  | 24.2 | 40.4 | 38.5 | 14.3 | 0.13 | 14.22 | 588 | 1.099 | 446 | 106.2 | 445 | 20.7 | 0.027 | 0.545 | 1.714 | 1499 | 954.3 | 0.002 | 11.49 | 2.0733 | 157.4 |
|  | 24.3 | 40.3 | 38.4 | 14.1 | 0.13 | 14.22 | 588 | 1.099 | 446 | 107.7 | 445 | 21 | 0.027 | 0.546 | 1.714 | 1499 | 954.3 | 0.002 | 11.49 | 2.0733 | 157.4 |
|  |  |  |  |  |  |  |  |  |  | 104.9 | 444 | 20.5 | 0.027 | 0.545 | 1.713 | 1499 | 954.3 | 0.002 | 11.48 |  |  |
| f ~ 585 | 24.3 | 32.8 | 31.7 | 7.41 | 0.1 | 10.66 | 588 | 1.2 | 532 | 118.2 | 531 | 23.1 | 0.027 | 0.596 | 1.872 | 1499 | 954.3 | 7E-04 | 13.7 | 2.2639 | 158.2 |
| L = 73 cm | 24.3 | 32.8 | 31.7 | 7.41 | 0.1 | 10.66 | 588 | 1.201 | 533 | 118.2 | 531 | 23.1 | 0.027 | 0.596 | 1.873 | 1499 | 954.3 | 7E-04 | 13.73 | 2.2658 | 158.2 |
| PR ~ 2.3 | 24.3 | 33.2 | 32.1 | 7.79 | 0.1 | 10.89 | 588 | 1.202 | 534 | 115 | 532 | 22.5 | 0.027 | 0.597 | 1.875 | 1499 | 954.3 | 7E-04 | 13.75 | 2.2677 | 158.2 |
|  |  |  |  |  |  |  |  |  |  | 117.1 | 531 | 22.9 | 0.027 | 0.596 | 1.873 | 1499 | 954.3 | 7E-04 | 13.73 |  |  |
|  | 24.4 | 36.4 | 35 | 10.6 | 0.11 | 12.85 | 588 | 1.2 | 532 | 110.1 | 531 | 21.5 | 0.027 | 0.596 | 1.872 | 1499 | 954.3 | 1E-03 | 13.71 | 2.2639 | 158.2 |
|  | 24.4 | 36.7 | 35.1 | 10.7 | 0.12 | 13.01 | 588 | 1.202 | 534 | 119.9 | 532 | 23.4 | 0.027 | 0.597 | 1.875 | 1499 | 954.3 | 1E-03 | 13.75 | 2.2677 | 158.2 |
|  | 24.5 | 37.3 | 35.7 | 11.2 | 0.12 | 13.35 | 588 | 1.201 | 533 | 118 | 532 | 23 | 0.027 | 0.596 | 1.874 | 1499 | 954.3 | 0.001 | 13.73 | 2.2658 | 158.2 |
|  |  |  |  |  |  |  |  |  |  | 116 | 532 | 22.7 | 0.027 | 0.596 | 1.874 | 1499 | 954.3 | 1E-03 | 13.73 |  |  |
|  | 24.7 | 40.3 | 38.3 | 13.6 | 0.13 | 14.76 | 588 | 1.202 | 535 | 115.6 | 533 | 22.6 | 0.027 | 0.597 | 1.876 | 1499 | 954.3 | 0.001 | 13.76 | 2.2677 | 158.2 |
|  | 24.7 | 40.7 | 38.7 | 14 | 0.13 | 14.94 | 588 | 1.2 | 533 | 113.9 | 531 | 22.3 | 0.027 | 0.596 | 1.873 | 1499 | 954.3 | 0.001 | 13.71 | 2.2639 | 158.2 |
|  | 24.8 | 41.1 | 39.1 | 14.3 | 0.13 | 15.08 | 588 | 1.198 | 531 | 112.7 | 529 | 22 | 0.027 | 0.595 | 1.87 | 1499 | 954.3 | 0.001 | 13.67 | 2.2601 | 158.2 |
|  |  |  |  |  |  |  |  |  |  | 114.1 | 531 | 22.3 | 0.027 | 0.596 | 1.873 | 1499 | 954.3 | 0.001 | 13.71 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1055 | 0.1831 | 14.301 | 7.1434 | 7.1434 | 0.9032 | 17.534 | 0.1684 | 0.5073 | 0.002 | 0.5345 |
| L = 73 cm | 0.1784 | 14.299 | 6.8744 | 6.8744 | 0.9016 | 17.315 | 0.1684 | 0.5069 | 0.002 | 0.5342 |
| PR ~ 2.5 | 0.1739 | 12.884 | 6.3773 | 6.3773 | 0.9895 | 15.759 | 0.1684 | 0.5069 | 0.002 | 0.5342 |
| | | | | | | 16.869 | | | | 0.5343 |
| | 0.1559 | 11.588 | 4.637 | 4.637 | 0.9351 | 13.349 | 0.1683 | 0.5069 | 0.002 | 0.5341 |
| | 0.1516 | 11.568 | 4.3718 | 4.3718 | 0.9178 | 13.149 | 0.1683 | 0.5069 | 0.002 | 0.5341 |
| | 0.1537 | 11.572 | 4.4801 | 4.4801 | 0.9216 | 13.226 | 0.1683 | 0.5081 | 0.002 | 0.5352 |
| | | | | | | 13.241 | | | | 0.5345 |
| | 0.1402 | 9.8114 | 3.4494 | 3.4494 | 0.9993 | 11.004 | 0.1683 | 0.5093 | 0.002 | 0.5363 |
| | 0.1393 | 9.8087 | 3.4062 | 3.4062 | 0.9965 | 10.974 | 0.1683 | 0.5093 | 0.002 | 0.5363 |
| | 0.138 | 9.8059 | 3.3437 | 3.3437 | 0.9937 | 10.933 | 0.1682 | 0.5104 | 0.002 | 0.5374 |
| | | | | | | 10.97 | | | | 0.5367 |
| f ~ 585 | 0.1689 | 13.152 | 7.1692 | 7.1692 | 1.1979 | 16.65 | 0.1686 | 0.5989 | 0.002 | 0.6222 |
| L = 73 cm | 0.1645 | 11.995 | 6.5656 | 6.5656 | 1.2854 | 15.225 | 0.1685 | 0.5995 | 0.002 | 0.6227 |
| PR ~ 2.1 | 0.1619 | 11.929 | 6.1743 | 6.1743 | 1.2281 | 14.835 | 0.1684 | 0.6005 | 0.002 | 0.6237 |
| | | | | | | 15.57 | | | | 0.6229 |
| | 0.1461 | 10.809 | 4.5079 | 4.5079 | 1.146 | 12.602 | 0.1684 | 0.6005 | 0.002 | 0.6237 |
| | 0.1445 | 10.026 | 4.2668 | 4.2668 | 1.2182 | 11.766 | 0.1684 | 0.6005 | 0.002 | 0.6237 |
| | 0.1491 | 10.808 | 4.6565 | 4.6565 | 1.1451 | 12.709 | 0.1683 | 0.6005 | 0.002 | 0.6237 |
| | | | | | | 12.359 | | | | 0.6237 |
| | 0.1372 | 9.9368 | 3.6762 | 3.6762 | 1.1275 | 11.272 | 0.1682 | 0.6016 | 0.002 | 0.6247 |
| | 0.1362 | 9.2707 | 3.4927 | 3.4927 | 1.188 | 10.572 | 0.1682 | 0.6005 | 0.002 | 0.6236 |
| | 0.1364 | 9.286 | 3.5422 | 3.5422 | 1.2048 | 10.62 | 0.1681 | 0.6005 | 0.002 | 0.6236 |
| | | | | | | 10.822 | | | | 0.624 |
| f ~ 585 | 0.1649 | 12.039 | 6.7446 | 6.7446 | 1.3229 | 15.417 | 0.1681 | 0.55 | 0.002 | 0.5751 |
| L = 73 cm | 0.1649 | 12.039 | 6.7446 | 6.7446 | 1.3229 | 15.417 | 0.1681 | 0.5495 | 0.002 | 0.5747 |
| PR ~ 2.3 | 0.162 | 11.996 | 6.4186 | 6.4186 | 1.2861 | 15.099 | 0.1681 | 0.5491 | 0.002 | 0.5742 |
| | | | | | | 15.311 | | | | 0.5747 |
| | 0.1453 | 10.9 | 4.7352 | 4.7352 | 1.2316 | 12.852 | 0.168 | 0.55 | 0.002 | 0.5751 |
| | 0.1457 | 10.146 | 4.6692 | 4.6692 | 1.3413 | 12.181 | 0.168 | 0.5491 | 0.002 | 0.5742 |
| | 0.1432 | 10.125 | 4.4775 | 4.4775 | 1.3198 | 12.016 | 0.168 | 0.5495 | 0.002 | 0.5746 |
| | | | | | | 12.35 | | | | 0.5747 |
| | 0.1347 | 9.3658 | 3.6642 | 3.6642 | 1.2928 | 10.782 | 0.1679 | 0.5491 | 0.002 | 0.5742 |
| | 0.1334 | 9.3492 | 3.5663 | 3.5663 | 1.2745 | 10.7 | 0.1679 | 0.55 | 0.002 | 0.5751 |
| | 0.1326 | 9.337 | 3.4961 | 3.4961 | 1.2611 | 10.641 | 0.1678 | 0.5509 | 0.002 | 0.5759 |
| | | | | | | 10.708 | | | | 0.575 |

| Experiment Information | T a (C) | T to (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs/Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 585 | 23 | 30.9 | 29.8 | 6.78 | 0.1 | 10.95 | 586 | 1.303 | 627 | 132.7 | 624 | 25.9 | 0.027 | 0.648 | 2.035 | 1494 | 951.1 | 5E-04 | 16.15 | 2.4582 | 158.9 |
| L = 73 cm | 22.9 | 31.2 | 30.1 | 7.16 | 0.1 | 11.22 | 587 | 1.303 | 625 | 128.9 | 624 | 25.2 | 0.027 | 0.646 | 2.031 | 1497 | 952.7 | 5E-04 | 16.13 | 2.4582 | 158.9 |
| PR ~ 2.5 | 22.9 | 31.2 | 30.1 | 7.17 | 0.1 | 11.13 | 587 | 1.303 | 625 | 127.7 | 624 | 25 | 0.027 | 0.646 | 2.031 | 1497 | 952.7 | 5E-04 | 16.13 | 2.4582 | 158.9 |
|  |  |  |  |  |  |  |  |  |  | 129.8 | 624 | 25.4 | 0.027 | 0.647 | 2.032 | 1496 | 952.2 | 5E-04 | 16.14 |  |  |
|  | 23.1 | 34.5 | 32.9 | 9.78 | 0.12 | 13.23 | 587 | 1.301 | 624 | 133.5 | 622 | 26.1 | 0.027 | 0.646 | 2.028 | 1497 | 952.7 | 7E-04 | 16.09 | 2.4544 | 158.9 |
|  | 23.3 | 35.1 | 33.4 | 10.1 | 0.12 | 13.56 | 587 | 1.3 | 623 | 131.9 | 622 | 25.8 | 0.027 | 0.645 | 2.028 | 1497 | 952.7 | 7E-04 | 16.07 | 2.4526 | 158.9 |
|  | 23.4 | 35.6 | 33.9 | 10.5 | 0.12 | 13.79 | 587 | 1.298 | 622 | 129.4 | 620 | 25.3 | 0.027 | 0.645 | 2.025 | 1497 | 952.7 | 7E-04 | 16.02 | 2.4488 | 158.9 |
|  |  |  |  |  |  |  |  |  |  | 131.6 | 621 | 25.7 | 0.027 | 0.645 | 2.027 | 1497 | 952.7 | 7E-04 | 16.06 |  |  |
|  | 23.6 | 38.7 | 36.7 | 13.1 | 0.13 | 15.28 | 587 | 1.296 | 620 | 124.9 | 618 | 24.4 | 0.027 | 0.644 | 2.022 | 1497 | 952.7 | 9E-04 | 15.98 | 2.445 | 158.9 |
|  | 23.7 | 39.3 | 37.1 | 13.4 | 0.14 | 15.6 | 587 | 1.297 | 621 | 134.3 | 619 | 26.2 | 0.027 | 0.644 | 2.024 | 1497 | 952.7 | 9E-04 | 16.01 | 2.4469 | 158.9 |
|  | 23.8 | 40.1 | 37.8 | 14 | 0.14 | 15.9 | 587 | 1.296 | 621 | 130.5 | 618 | 25.5 | 0.027 | 0.644 | 2.023 | 1497 | 952.7 | 1E-03 | 15.98 | 2.445 | 158.9 |
|  |  |  |  |  |  |  |  |  |  | 129.9 | 619 | 25.4 | 0.027 | 0.644 | 2.023 | 1497 | 952.7 | 9E-04 | 15.99 |  |  |
| f ~ 585 | 23.6 | 31.2 | 30 | 6.45 | 0.1 | 11.33 | 587 | 1.403 | 727 | 144.6 | 724 | 28.2 | 0.027 | 0.697 | 2.189 | 1497 | 952.7 | 3E-04 | 18.73 | 2.6469 | 159.5 |
| L = 73 cm | 23.7 | 32.3 | 30.9 | 7.25 | 0.11 | 12.05 | 587 | 1.402 | 726 | 150.4 | 724 | 29.4 | 0.027 | 0.696 | 2.188 | 1497 | 952.7 | 4E-04 | 18.7 | 2.645 | 159.5 |
| PR ~ 2.6 | 23.7 | 32.6 | 31.2 | 7.51 | 0.11 | 12.38 | 587 | 1.403 | 727 | 149.1 | 725 | 29.1 | 0.027 | 0.697 | 2.19 | 1497 | 952.7 | 4E-04 | 18.73 | 2.6469 | 159.5 |
|  |  |  |  |  |  |  |  |  |  | 148 | 724 | 28.9 | 0.027 | 0.697 | 2.189 | 1497 | 952.7 | 4E-04 | 18.72 |  |  |
|  | 23.9 | 35.4 | 33.5 | 9.63 | 0.13 | 14.1 | 587 | 1.4 | 724 | 156.5 | 722 | 30.6 | 0.027 | 0.696 | 2.186 | 1497 | 952.7 | 5E-04 | 18.66 | 2.6412 | 159.5 |
|  | 24 | 36.2 | 34.3 | 10.3 | 0.13 | 14.52 | 588 | 1.405 | 729 | 151.1 | 727 | 29.5 | 0.027 | 0.697 | 2.19 | 1499 | 954.3 | 5E-04 | 18.77 | 2.6506 | 159.6 |
|  | 24 | 36.6 | 34.7 | 10.7 | 0.13 | 14.63 | 588 | 1.406 | 730 | 146.7 | 728 | 28.7 | 0.027 | 0.698 | 2.192 | 1499 | 954.3 | 5E-04 | 18.8 | 2.6525 | 159.6 |
|  |  |  |  |  |  |  |  |  |  | 151.4 | 725 | 29.6 | 0.027 | 0.697 | 2.189 | 1498 | 953.8 | 5E-04 | 18.74 |  |  |
|  | 24.3 | 39.7 | 37.4 | 13.1 | 0.14 | 16.21 | 588 | 1.402 | 726 | 142.6 | 724 | 27.9 | 0.027 | 0.696 | 2.187 | 1499 | 954.3 | 7E-04 | 18.7 | 2.645 | 159.5 |
|  | 24.4 | 40.3 | 37.8 | 13.4 | 0.15 | 16.48 | 588 | 1.402 | 726 | 151.9 | 724 | 29.7 | 0.027 | 0.696 | 2.187 | 1499 | 954.3 | 7E-04 | 18.71 | 2.645 | 159.5 |
|  | 24.4 | 40.3 | 37.8 | 13.4 | 0.15 | 16.5 | 588 | 1.405 | 730 | 152.1 | 727 | 29.7 | 0.027 | 0.698 | 2.192 | 1499 | 954.3 | 7E-04 | 18.79 | 2.6506 | 159.6 |
|  |  |  |  |  |  |  |  |  |  | 148.9 | 725 | 29.1 | 0.027 | 0.697 | 2.188 | 1499 | 954.3 | 7E-04 | 18.73 |  |  |
| f ~ 585 | 24.3 | 32.9 | 31.5 | 7.2 | 0.11 | 12.5 | 588 | 1.501 | 832 | 157.1 | 830 | 30.7 | 0.027 | 0.745 | 2.341 | 1499 | 954.3 | 3E-04 | 21.44 | 2.8318 | 160.1 |
| L = 73 cm | 24.3 | 32.6 | 31.2 | 6.93 | 0.11 | 12.25 | 588 | 1.5 | 831 | 160 | 829 | 31.3 | 0.027 | 0.745 | 2.339 | 1499 | 954.3 | 3E-04 | 21.41 | 2.8299 | 160.1 |
| PR ~ 2.8 | 22.8 | 31.1 | 29.7 | 6.92 | 0.11 | 12.34 | 587 | 1.504 | 833 | 161.4 | 831 | 31.5 | 0.027 | 0.746 | 2.344 | 1497 | 952.7 | 3E-04 | 21.48 | 2.8374 | 160.1 |
|  |  |  |  |  |  |  |  |  |  | 159.5 | 830 | 31.2 | 0.027 | 0.745 | 2.341 | 1498 | 953.8 | 3E-04 | 21.44 |  |  |
|  | 23.1 | 35.3 | 33.3 | 10.2 | 0.13 | 15.09 | 587 | 1.501 | 830 | 158.1 | 828 | 30.9 | 0.027 | 0.745 | 2.34 | 1497 | 952.7 | 4E-04 | 21.41 | 2.8318 | 160.1 |
|  | 23.2 | 35.3 | 33.3 | 10.1 | 0.13 | 14.92 | 587 | 1.5 | 830 | 157.6 | 827 | 30.8 | 0.027 | 0.745 | 2.339 | 1497 | 952.7 | 4E-04 | 21.39 | 2.8299 | 160.1 |
|  | 23.3 | 35.7 | 33.7 | 10.4 | 0.13 | 15.1 | 587 | 1.499 | 829 | 155.2 | 826 | 30.3 | 0.027 | 0.744 | 2.338 | 1497 | 952.7 | 4E-04 | 21.36 | 2.828 | 160.1 |
|  |  |  |  |  |  |  |  |  |  | 157 | 827 | 30.7 | 0.027 | 0.745 | 2.339 | 1497 | 952.7 | 4E-04 | 21.39 |  |  |
|  | 23.4 | 39 | 36.4 | 13 | 0.15 | 16.96 | 587 | 1.498 | 828 | 160.8 | 826 | 31.4 | 0.027 | 0.744 | 2.337 | 1497 | 952.7 | 5E-04 | 21.34 | 2.8261 | 160.1 |
|  | 23.5 | 39.4 | 36.8 | 13.3 | 0.15 | 17.13 | 587 | 1.495 | 825 | 159.1 | 822 | 31.1 | 0.027 | 0.742 | 2.332 | 1497 | 952.7 | 5E-04 | 21.26 | 2.8204 | 160.1 |
|  | 23.8 | 39.2 | 36.6 | 12.8 | 0.15 | 16.86 | 588 | 1.501 | 831 | 162.2 | 829 | 31.7 | 0.027 | 0.745 | 2.339 | 1499 | 954.3 | 5E-04 | 21.42 | 2.8318 | 160.1 |
|  |  |  |  |  |  |  |  |  |  | 160.7 | 826 | 31.4 | 0.027 | 0.744 | 2.336 | 1497 | 953.3 | 5E-04 | 21.34 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | To uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mid V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 585 | 0.1646 | 12.228 | 7.3705 | 7.3705 | 1.485 | 16.137 | 0.1688 | 0.5065 | 0.002 | 0.5339 |
| L = 73 cm | 0.1614 | 12.178 | 6.9869 | 6.9869 | 1.4424 | 15.749 | 0.1689 | 0.5065 | 0.002 | 0.5339 |
| PR ~ 2.5 | 0.162 | 12.163 | 6.9779 | 6.9779 | 1.429 | 15.728 | 0.1689 | 0.5065 | 0.002 | 0.5339 |
| | | | | | | 15.872 | | | | 0.5339 |
| | 0.1464 | 10.295 | 5.1116 | 5.1116 | 1.4932 | 12.668 | 0.1688 | 0.5073 | 0.002 | 0.5346 |
| | 0.144 | 10.278 | 4.9303 | 4.9303 | 1.4762 | 12.508 | 0.1687 | 0.5077 | 0.002 | 0.535 |
| | 0.1422 | 10.251 | 4.7559 | 4.7559 | 1.4481 | 12.346 | 0.1686 | 0.5085 | 0.002 | 0.5357 |
| | | | | | | 12.508 | | | | 0.5351 |
| | 0.1333 | 9.461 | 3.8241 | 3.8241 | 1.3977 | 10.988 | 0.1685 | 0.5093 | 0.002 | 0.5364 |
| | 0.1331 | 8.9152 | 3.7387 | 3.7387 | 1.5024 | 10.474 | 0.1684 | 0.5089 | 0.002 | 0.536 |
| | 0.1312 | 8.8789 | 3.5636 | 3.5636 | 1.4596 | 10.314 | 0.1684 | 0.5093 | 0.002 | 0.5364 |
| | | | | | | 10.592 | | | | 0.5363 |
| f ~ 585 | 0.163 | 12.382 | 7.7579 | 7.7579 | 1.6173 | 16.623 | 0.1685 | 0.4704 | 0.002 | 0.4997 |
| L = 73 cm | 0.1578 | 11.379 | 6.8977 | 6.8977 | 1.6823 | 15.083 | 0.1684 | 0.4708 | 0.002 | 0.5 |
| PR ~ 2.6 | 0.1549 | 11.363 | 6.6562 | 6.6562 | 1.6678 | 14.851 | 0.1684 | 0.4704 | 0.002 | 0.4997 |
| | | | | | | 15.519 | | | | 0.4998 |
| | 0.1444 | 9.7816 | 5.1913 | 5.1913 | 1.7509 | 12.356 | 0.1683 | 0.4714 | 0.002 | 0.5006 |
| | 0.1411 | 9.7263 | 4.8658 | 4.8658 | 1.69 | 12.034 | 0.1683 | 0.4698 | 0.002 | 0.499 |
| | 0.1399 | 9.6821 | 4.6899 | 4.6899 | 1.6412 | 11.851 | 0.1683 | 0.4694 | 0.002 | 0.4987 |
| | | | | | | 12.08 | | | | 0.4994 |
| | 0.1314 | 8.9939 | 3.8207 | 3.8207 | 1.5954 | 10.614 | 0.1681 | 0.4708 | 0.002 | 0.4999 |
| | 0.1315 | 8.5164 | 3.7369 | 3.7369 | 1.6997 | 10.167 | 0.168 | 0.4708 | 0.002 | 0.4999 |
| | 0.1315 | 8.5183 | 3.7377 | 3.7377 | 1.7022 | 10.169 | 0.168 | 0.4698 | 0.002 | 0.4989 |
| | | | | | | 10.317 | | | | 0.4995 |
| f ~ 585 | 0.1553 | 11.458 | 6.946 | 6.946 | 1.7573 | 15.195 | 0.1681 | 0.4397 | 0.002 | 0.4707 |
| L = 73 cm | 0.1577 | 11.493 | 7.2188 | 7.2188 | 1.7898 | 15.477 | 0.1681 | 0.44 | 0.002 | 0.471 |
| PR ~ 2.8 | 0.1573 | 11.51 | 7.2293 | 7.2293 | 1.8056 | 15.501 | 0.1689 | 0.4388 | 0.002 | 0.4702 |
| | | | | | | 15.391 | | | | 0.4707 |
| | 0.1391 | 9.7983 | 4.9018 | 4.9018 | 1.7693 | 12.133 | 0.1688 | 0.4397 | 0.002 | 0.471 |
| | 0.1399 | 9.7924 | 4.9393 | 4.9393 | 1.7628 | 12.158 | 0.1687 | 0.44 | 0.002 | 0.4712 |
| | 0.1386 | 9.7687 | 4.8082 | 4.8082 | 1.7367 | 12.029 | 0.1687 | 0.4403 | 0.002 | 0.4715 |
| | | | | | | 12.107 | | | | 0.4712 |
| | 0.1307 | 8.5956 | 3.8442 | 3.8442 | 1.7994 | 10.329 | 0.1686 | 0.4406 | 0.002 | 0.4718 |
| | 0.1298 | 8.5801 | 3.7649 | 3.7649 | 1.78 | 10.254 | 0.1685 | 0.4415 | 0.002 | 0.4726 |
| | 0.1313 | 8.6076 | 3.8995 | 3.8995 | 1.8146 | 10.383 | 0.1684 | 0.4397 | 0.002 | 0.4708 |
| | | | | | | 10.322 | | | | 0.4717 |

| Experiment Information | Ta (C) | Tfc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 585 | 23.7 | 32.4 | 30.8 | 7.07 | 0.12 | 13.29 | 588 | 1.605 | 950 | 185.4 | 948 | 36.2 | 0.027 | 0.796 | 2.501 | 1499 | 954.3 | 2E-04 | 24.48 | 3.028 | 160.7 |
| L = 73 cm | 23.7 | 32.1 | 30.5 | 6.81 | 0.12 | 12.97 | 588 | 1.608 | 953 | 187.8 | 951 | 36.7 | 0.027 | 0.797 | 2.505 | 1499 | 954.3 | 2E-04 | 24.57 | 3.0336 | 160.7 |
| PR ~ 3.0 | 23.7 | 32.2 | 30.6 | 6.9 | 0.12 | 13.05 | 588 | 1.608 | 953 | 186.5 | 951 | 36.4 | 0.027 | 0.797 | 2.505 | 1499 | 954.3 | 2E-04 | 24.57 | 3.0336 | 160.7 |
|  |  |  |  |  |  |  |  |  |  | 186.6 | 950 | 36.5 | 0.027 | 0.797 | 2.504 | 1499 | 954.3 | 2E-04 | 24.54 |  |  |
|  | 23.9 | 35.8 | 33.6 | 9.72 | 0.14 | 15.28 | 588 | 1.606 | 952 | 181 | 949 | 35.4 | 0.027 | 0.797 | 2.503 | 1499 | 954.3 | 3E-04 | 24.52 | 3.0298 | 160.7 |
|  | 24 | 36.1 | 33.9 | 9.91 | 0.14 | 15.35 | 588 | 1.604 | 950 | 178.3 | 947 | 34.8 | 0.027 | 0.796 | 2.5 | 1499 | 954.3 | 3E-04 | 24.47 | 3.0261 | 160.7 |
|  | 24 | 36.3 | 34.1 | 10.1 | 0.14 | 15.46 | 588 | 1.603 | 948 | 176.3 | 946 | 34.5 | 0.027 | 0.795 | 2.499 | 1499 | 954.3 | 3E-04 | 24.44 | 3.0242 | 160.7 |
|  |  |  |  |  |  |  |  |  |  | 178.5 | 948 | 34.9 | 0.027 | 0.796 | 2.501 | 1499 | 954.3 | 3E-04 | 24.48 |  |  |
|  | 24.1 | 39.2 | 36.6 | 12.5 | 0.15 | 17.2 | 588 | 1.603 | 949 | 170.1 | 946 | 33.2 | 0.027 | 0.796 | 2.499 | 1499 | 954.3 | 4E-04 | 24.44 | 3.0242 | 160.7 |
|  | 24.2 | 39.6 | 36.9 | 12.7 | 0.15 | 17.49 | 588 | 1.6 | 945 | 169.5 | 943 | 33.1 | 0.027 | 0.794 | 2.495 | 1499 | 954.3 | 4E-04 | 24.36 | 3.0185 | 160.7 |
|  | 24.2 | 39.8 | 37.1 | 12.9 | 0.15 | 17.6 | 588 | 1.601 | 947 | 168.2 | 944 | 32.9 | 0.027 | 0.795 | 2.497 | 1499 | 954.3 | 4E-04 | 24.39 | 3.0204 | 160.7 |
|  |  |  |  |  |  |  |  |  |  | 169.3 | 945 | 33.1 | 0.027 | 0.795 | 2.497 | 1499 | 954.3 | 4E-04 | 24.39 |  |  |
| f ~ 585 | 21.9 | 31.1 | 29.4 | 7.5 | 0.12 | 13.91 | 586 | 1.701 | 1064 | 183 | 1062 | 35.8 | 0.027 | 0.844 | 2.651 | 1494 | 951.1 | 2E-04 | 27.46 | 3.2091 | 161.2 |
| L = 73 cm | 22.2 | 30.9 | 29.3 | 7.05 | 0.12 | 13.48 | 586 | 1.7 | 1064 | 188.6 | 1061 | 36.9 | 0.027 | 0.844 | 2.651 | 1494 | 951.1 | 2E-04 | 27.45 | 3.2072 | 161.2 |
| PR ~ 3.2 | 22.2 | 30.7 | 29.1 | 6.88 | 0.12 | 13.21 | 586 | 1.699 | 1063 | 189.4 | 1060 | 37 | 0.027 | 0.843 | 2.649 | 1494 | 951.1 | 2E-04 | 27.42 | 3.2053 | 161.2 |
|  |  |  |  |  |  |  |  |  |  | 187 | 1061 | 36.5 | 0.027 | 0.844 | 2.651 | 1494 | 951.1 | 2E-04 | 27.44 |  |  |
|  | 22.4 | 34.3 | 32.1 | 9.65 | 0.14 | 15.76 | 587 | 1.705 | 1069 | 188 | 1067 | 36.7 | 0.027 | 0.845 | 2.655 | 1497 | 952.7 | 2E-04 | 27.59 | 3.2166 | 161.2 |
|  | 22.5 | 34.3 | 32 | 9.54 | 0.14 | 15.87 | 587 | 1.707 | 1072 | 191.6 | 1070 | 37.4 | 0.027 | 0.846 | 2.659 | 1497 | 952.7 | 2E-04 | 27.66 | 3.2204 | 161.2 |
|  | 22.6 | 34.6 | 32.3 | 9.72 | 0.14 | 16.01 | 587 | 1.708 | 1073 | 189.7 | 1071 | 37.1 | 0.027 | 0.847 | 2.661 | 1497 | 952.7 | 2E-04 | 27.7 | 3.2223 | 161.2 |
|  |  |  |  |  |  |  |  |  |  | 189.8 | 1070 | 37.1 | 0.027 | 0.846 | 2.658 | 1497 | 952.7 | 2E-04 | 27.65 |  |  |
|  | 22.9 | 37.7 | 34.8 | 11.9 | 0.16 | 17.67 | 587 | 1.706 | 1072 | 195.1 | 1070 | 38.1 | 0.027 | 0.846 | 2.659 | 1497 | 952.7 | 3E-04 | 27.65 | 3.2185 | 161.2 |
|  | 23.1 | 39 | 36 | 12.9 | 0.16 | 18.39 | 587 | 1.705 | 1072 | 187.6 | 1069 | 36.6 | 0.027 | 0.846 | 2.658 | 1497 | 952.7 | 3E-04 | 27.63 | 3.2166 | 161.2 |
|  | 23.2 | 39.1 | 36.1 | 12.9 | 0.16 | 18.39 | 587 | 1.704 | 1071 | 187.6 | 1068 | 36.6 | 0.027 | 0.846 | 2.657 | 1497 | 952.7 | 3E-04 | 27.6 | 3.2147 | 161.2 |
|  |  |  |  |  |  |  |  |  |  | 190.1 | 1069 | 37.1 | 0.027 | 0.846 | 2.658 | 1497 | 952.7 | 3E-04 | 27.63 |  |  |
| f ~ 1055 | 23 | 31.5 | 30.8 | 7.83 | 0.08 | 8.23 | 1053 | 1.057 | 229 | 69.15 | 225 | 13.5 | 0.049 | 0.292 | 0.919 | 2685 | 1709 | 0.004 | 4.348 | 1.9941 | 157.1 |
| L = 73 cm | 23 | 31.5 | 30.8 | 7.83 | 0.08 | 8.23 | 1053 | 1.061 | 231 | 69.15 | 227 | 13.5 | 0.049 | 0.293 | 0.922 | 2685 | 1709 | 0.004 | 4.381 | 2.0017 | 157.1 |
| PR ~ 2.0 | 23 | 31.6 | 30.9 | 7.92 | 0.08 | 8.29 | 1053 | 1.061 | 231 | 68.82 | 227 | 13.4 | 0.049 | 0.293 | 0.922 | 2685 | 1709 | 0.004 | 4.381 | 2.0017 | 157.1 |
|  |  |  |  |  |  |  |  |  |  | 69.04 | 226 | 13.5 | 0.049 | 0.293 | 0.921 | 2685 | 1709 | 0.004 | 4.37 |  |  |
|  | 23 | 35.4 | 34.5 | 11.5 | 0.09 | 10.12 | 1053 | 1.054 | 228 | 65.29 | 224 | 12.8 | 0.049 | 0.292 | 0.916 | 2685 | 1709 | 0.006 | 4.323 | 1.9885 | 157.1 |
|  | 23.1 | 35.6 | 34.7 | 11.6 | 0.09 | 10.24 | 1053 | 1.061 | 227 | 65.55 | 223 | 12.8 | 0.049 | 0.291 | 0.913 | 2685 | 1709 | 0.006 | 4.297 | 1.9828 | 157 |
|  | 23.1 | 35.6 | 34.7 | 11.6 | 0.09 | 10.24 | 1053 | 1.051 | 227 | 65.55 | 223 | 12.8 | 0.049 | 0.291 | 0.913 | 2685 | 1709 | 0.006 | 4.297 | 1.9828 | 157 |
|  |  |  |  |  |  |  |  |  |  | 65.46 | 223 | 12.8 | 0.049 | 0.291 | 0.914 | 2685 | 1709 | 0.006 | 4.306 |  |  |
|  | 23.2 | 40 | 38.6 | 15.4 | 0.11 | 12.26 | 1054 | 1.059 | 230 | 71.89 | 227 | 14 | 0.049 | 0.293 | 0.92 | 2687 | 1711 | 0.008 | 4.371 | 1.9979 | 157.1 |
|  | 23.2 | 39.8 | 38.4 | 15.2 | 0.11 | 12.04 | 1054 | 1.059 | 230 | 71.41 | 227 | 14 | 0.049 | 0.293 | 0.92 | 2687 | 1711 | 0.008 | 4.371 | 1.9979 | 157.1 |
|  | 23.2 | 40 | 38.6 | 15.4 | 0.11 | 12.18 | 1054 | 1.06 | 231 | 71.38 | 227 | 13.9 | 0.049 | 0.293 | 0.921 | 2687 | 1711 | 0.008 | 4.379 | 1.9998 | 157.1 |
|  |  |  |  |  |  |  |  |  |  | 71.56 | 227 | 14 | 0.049 | 0.293 | 0.92 | 2687 | 1711 | 0.008 | 4.374 |  |  |

| Experiment Information | V uncert | f uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 585 | 0.154 | 10.863 | 7.0678 | 7.0678 | 2.074 | 14.908 | 0.1684 | 0.4112 | 0.002 | 0.4444 |
| L = 73 cm | 0.1567 | 10.89 | 7.3384 | 7.3384 | 2.1016 | 15.19 | 0.1684 | 0.4104 | 0.002 | 0.4437 |
| PR ~ 3.0 | 0.1559 | 10.876 | 7.2425 | 7.2425 | 2.0869 | 15.085 | 0.1684 | 0.4104 | 0.002 | 0.4437 |
| | | | | | | 15.061 | | | | 0.4439 |
| | 0.1413 | 9.3576 | 5.1444 | 5.1444 | 2.0249 | 12.026 | 0.1683 | 0.411 | 0.002 | 0.4441 |
| | 0.1406 | 9.3324 | 5.0457 | 5.0457 | 1.9952 | 11.917 | 0.1683 | 0.4115 | 0.002 | 0.4446 |
| | 0.1398 | 9.3135 | 4.9536 | 4.9536 | 1.9728 | 11.821 | 0.1683 | 0.4117 | 0.002 | 0.4448 |
| | | | | | | 11.921 | | | | 0.4445 |
| | 0.1309 | 8.6781 | 4.0096 | 4.0096 | 1.9034 | 10.541 | 0.1682 | 0.4117 | 0.002 | 0.4448 |
| | 0.1297 | 8.6727 | 3.9291 | 3.9291 | 1.8967 | 10.474 | 0.1682 | 0.4125 | 0.002 | 0.4455 |
| | 0.1291 | 8.6607 | 3.8733 | 3.8733 | 1.8815 | 10.42 | 0.1682 | 0.4122 | 0.002 | 0.4452 |
| | | | | | | 10.478 | | | | 0.4452 |
| f ~ 585 | 0.1495 | 10.838 | 6.668 | 6.668 | 2.048 | 14.512 | 0.1695 | 0.388 | 0.002 | 0.4234 |
| L = 73 cm | 0.1532 | 10.899 | 7.0911 | 7.0911 | 2.1106 | 14.961 | 0.1693 | 0.3882 | 0.002 | 0.4235 |
| PR ~ 3.2 | 0.1552 | 10.907 | 7.2631 | 7.2631 | 2.1185 | 15.132 | 0.1693 | 0.3885 | 0.002 | 0.4238 |
| | | | | | | 14.868 | | | | 0.4236 |
| | 0.1399 | 9.424 | 5.1809 | 5.1809 | 2.1033 | 12.122 | 0.1692 | 0.3871 | 0.002 | 0.4225 |
| | 0.1399 | 9.4582 | 5.2437 | 5.2437 | 2.1437 | 12.209 | 0.1691 | 0.3866 | 0.002 | 0.422 |
| | 0.1389 | 9.4403 | 5.1466 | 5.1466 | 2.1225 | 12.109 | 0.1691 | 0.3864 | 0.002 | 0.4218 |
| | | | | | | 12.147 | | | | 0.4221 |
| | 0.1324 | 8.3822 | 4.1953 | 4.1953 | 2.1824 | 10.5 | 0.1689 | 0.3869 | 0.002 | 0.4221 |
| | 0.1286 | 8.3194 | 3.8758 | 3.8758 | 2.0984 | 10.182 | 0.1688 | 0.3871 | 0.002 | 0.4223 |
| | 0.1286 | 8.3194 | 3.8758 | 3.8758 | 2.0984 | 10.182 | 0.1687 | 0.3873 | 0.002 | 0.4225 |
| | | | | | | 10.288 | | | | 0.4223 |
| f ~ 1055 | 0.1862 | 14.114 | 6.3866 | 6.3866 | 0.7737 | 16.776 | 0.1688 | 0.6244 | 0.002 | 0.6468 |
| L = 73 cm | 0.1862 | 14.114 | 6.3866 | 6.3866 | 0.7737 | 16.776 | 0.1688 | 0.6221 | 0.002 | 0.6446 |
| PR ~ 2.0 | 0.1852 | 14.109 | 6.31 | 6.31 | 0.77 | 16.713 | 0.1688 | 0.6221 | 0.002 | 0.6446 |
| | | | | | | 16.755 | | | | 0.6453 |
| | 0.1609 | 12.551 | 4.3586 | 4.3586 | 0.7304 | 14.003 | 0.1688 | 0.6262 | 0.002 | 0.6486 |
| | 0.1597 | 12.555 | 4.3251 | 4.3251 | 0.7334 | 13.986 | 0.1688 | 0.628 | 0.002 | 0.6503 |
| | 0.1597 | 12.555 | 4.3251 | 4.3251 | 0.7334 | 13.986 | 0.1688 | 0.628 | 0.002 | 0.6503 |
| | | | | | | 13.991 | | | | 0.6497 |
| | 0.1433 | 10.446 | 3.2414 | 3.2414 | 0.8043 | 11.436 | 0.1687 | 0.6232 | 0.002 | 0.6457 |
| | 0.1448 | 10.44 | 3.2787 | 3.2787 | 0.799 | 11.452 | 0.1687 | 0.6232 | 0.002 | 0.6457 |
| | 0.1438 | 10.44 | 3.2395 | 3.2395 | 0.7986 | 11.429 | 0.1687 | 0.6226 | 0.002 | 0.6451 |
| | | | | | | 11.439 | | | | 0.6455 |

| Experiment Information | Ta (C) | Tto (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | $\frac{Rs}{\Lambda}$ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1055 Hz | 23.2 | 31.7 | 31 | 7.81 | 0.08 | 8.52 | 1054 | 1.148 | 271 | 71.81 | 266 | 14 | 0.049 | 0.317 | 0.997 | 2687 | 1711 | 0.003 | 5.137 | 2.1658 | 157.8 |
| L = 73 cm | 23.2 | 31.9 | 31.2 | 7.99 | 0.08 | 8.66 | 1054 | 1.15 | 272 | 71.27 | 267 | 13.9 | 0.049 | 0.318 | 0.999 | 2687 | 1711 | 0.003 | 5.155 | 2.1696 | 157.8 |
| PR ~ 2.2 | 23.2 | 31.9 | 31.2 | 7.99 | 0.08 | 8.66 | 1054 | 1.151 | 272 | 71.27 | 268 | 13.9 | 0.049 | 0.318 | 1 | 2687 | 1711 | 0.003 | 5.164 | 2.1715 | 157.8 |
| | | | | | | | | | | 71.45 | 267 | 14 | 0.049 | 0.318 | 0.998 | 2687 | 1711 | 0.003 | 5.152 | | |
| | 23.2 | 35.2 | 34.2 | 11 | 0.09 | 10.36 | 1054 | 1.154 | 273 | 69.39 | 269 | 13.6 | 0.049 | 0.319 | 1.002 | 2687 | 1711 | 0.004 | 5.19 | 2.1771 | 157.8 |
| | 23.3 | 35.2 | 34.3 | 11 | 0.09 | 10.27 | 1054 | 1.148 | 271 | 69.36 | 266 | 13.6 | 0.049 | 0.317 | 0.997 | 2687 | 1711 | 0.004 | 5.135 | 2.1658 | 157.8 |
| | 23.3 | 35.3 | 34.3 | 11 | 0.09 | 10.39 | 1054 | 1.15 | 272 | 69.61 | 267 | 13.6 | 0.049 | 0.318 | 0.999 | 2687 | 1711 | 0.004 | 5.153 | 2.1696 | 157.8 |
| | | | | | | | | | | 69.45 | 267 | 13.6 | 0.049 | 0.318 | 0.999 | 2687 | 1711 | 0.004 | 5.16 | | |
| | 23.3 | 39.3 | 37.9 | 14.6 | 0.11 | 12.24 | 1054 | 1.149 | 271 | 75.69 | 267 | 14.8 | 0.049 | 0.318 | 0.998 | 2687 | 1711 | 0.006 | 5.144 | 2.1677 | 157.8 |
| | 23.5 | 39.6 | 38.2 | 14.7 | 0.11 | 12.38 | 1054 | 1.148 | 271 | 76.12 | 266 | 14.9 | 0.049 | 0.318 | 0.997 | 2687 | 1711 | 0.006 | 5.132 | 2.1658 | 157.8 |
| | 23.5 | 39.7 | 38.3 | 14.8 | 0.11 | 12.38 | 1054 | 1.148 | 271 | 75.6 | 266 | 14.8 | 0.049 | 0.318 | 0.997 | 2687 | 1711 | 0.006 | 5.132 | 2.1658 | 157.8 |
| | | | | | | | | | | 75.8 | 266 | 14.8 | 0.049 | 0.318 | 0.998 | 2687 | 1711 | 0.006 | 5.136 | | |
| f ~ 1055 Hz | 22.8 | 31.1 | 30.4 | 7.57 | 0.08 | 8.91 | 1054 | 1.249 | 320 | 77.39 | 315 | 15.1 | 0.049 | 0.345 | 1.084 | 2687 | 1711 | 0.002 | 6.086 | 2.3563 | 158.5 |
| L = 73 cm | 22.9 | 31.2 | 30.5 | 7.57 | 0.08 | 9 | 1054 | 1.254 | 323 | 78.25 | 318 | 15.3 | 0.049 | 0.346 | 1.088 | 2687 | 1711 | 0.002 | 6.134 | 2.3658 | 158.6 |
| PR ~ 2.4 | 22.9 | 31.3 | 30.6 | 7.66 | 0.08 | 9.07 | 1054 | 1.252 | 322 | 77.89 | 317 | 15.2 | 0.049 | 0.346 | 1.087 | 2687 | 1711 | 0.002 | 6.114 | 2.362 | 158.6 |
| | | | | | | | | | | 77.85 | 317 | 15.2 | 0.049 | 0.346 | 1.086 | 2687 | 1711 | 0.002 | 6.111 | | |
| | 23.2 | 34.6 | 33.5 | 10.3 | 0.1 | 10.51 | 1054 | 1.243 | 317 | 83.67 | 312 | 16.3 | 0.049 | 0.344 | 1.079 | 2687 | 1711 | 0.003 | 6.022 | 2.345 | 158.5 |
| | 23.2 | 35 | 33.9 | 10.7 | 0.1 | 10.9 | 1055 | 1.245 | 318 | 83.85 | 314 | 16.4 | 0.049 | 0.344 | 1.08 | 2690 | 1712 | 0.003 | 6.052 | 2.3488 | 158.5 |
| | 23.2 | 35.4 | 34.3 | 11.1 | 0.1 | 11.08 | 1055 | 1.249 | 320 | 82.3 | 316 | 16.1 | 0.049 | 0.345 | 1.084 | 2690 | 1712 | 0.003 | 6.091 | 2.3563 | 158.5 |
| | | | | | | | | | | 83.28 | 314 | 16.3 | 0.049 | 0.344 | 1.081 | 2689 | 1712 | 0.003 | 6.055 | | |
| | 23.4 | 39.7 | 38.1 | 14.7 | 0.12 | 12.96 | 1055 | 1.254 | 323 | 86.91 | 318 | 17 | 0.049 | 0.346 | 1.088 | 2690 | 1712 | 0.004 | 6.137 | 2.3658 | 158.6 |
| | 23.4 | 39.8 | 38.2 | 14.8 | 0.12 | 13.03 | 1055 | 1.254 | 323 | 86.84 | 318 | 17 | 0.049 | 0.346 | 1.088 | 2690 | 1712 | 0.004 | 6.137 | 2.3658 | 158.6 |
| | 23.5 | 40.1 | 38.5 | 15 | 0.12 | 13.1 | 1055 | 1.255 | 323 | 86.19 | 319 | 16.8 | 0.049 | 0.347 | 1.089 | 2690 | 1712 | 0.004 | 6.146 | 2.3677 | 158.6 |
| | | | | | | | | | | 86.65 | 318 | 16.9 | 0.049 | 0.347 | 1.089 | 2690 | 1712 | 0.004 | 6.14 | | |
| f ~ 1055 Hz | 23.4 | 31.4 | 30.7 | 7.26 | 0.08 | 9.08 | 1055 | 1.363 | 381 | 82.28 | 376 | 16.1 | 0.049 | 0.377 | 1.183 | 2690 | 1712 | 0.001 | 7.251 | 2.5714 | 159.3 |
| L = 73 cm | 23.4 | 31.5 | 30.8 | 7.35 | 0.08 | 9.19 | 1055 | 1.362 | 381 | 82.25 | 375 | 16.1 | 0.049 | 0.376 | 1.182 | 2690 | 1712 | 0.001 | 7.24 | 2.5695 | 159.3 |
| PR ~ 2.6 | 23.4 | 31.7 | 31 | 7.55 | 0.08 | 9.19 | 1055 | 1.361 | 380 | 80.07 | 375 | 15.6 | 0.049 | 0.376 | 1.181 | 2690 | 1712 | 0.001 | 7.229 | 2.5676 | 159.3 |
| | | | | | | | | | | 81.53 | 375 | 15.9 | 0.049 | 0.376 | 1.182 | 2690 | 1712 | 0.001 | 7.24 | | |
| | 23.5 | 35.4 | 34.3 | 10.8 | 0.1 | 11.28 | 1055 | 1.36 | 380 | 86.28 | 374 | 16.9 | 0.049 | 0.376 | 1.181 | 2690 | 1712 | 0.002 | 7.217 | 2.5657 | 159.3 |
| | 23.6 | 36 | 34.8 | 11.2 | 0.1 | 11.44 | 1055 | 1.36 | 380 | 83.74 | 374 | 16.4 | 0.049 | 0.376 | 1.181 | 2690 | 1712 | 0.002 | 7.215 | 2.5657 | 159.3 |
| | 23.6 | 36 | 34.8 | 11.2 | 0.1 | 11.44 | 1055 | 1.359 | 379 | 83.74 | 374 | 16.4 | 0.049 | 0.376 | 1.18 | 2690 | 1712 | 0.002 | 7.205 | 2.5639 | 159.3 |
| | | | | | | | | | | 84.59 | 374 | 16.5 | 0.049 | 0.376 | 1.18 | 2690 | 1712 | 0.002 | 7.212 | | |
| | 23.7 | 40 | 38.4 | 14.7 | 0.12 | 13.45 | 1055 | 1.356 | 378 | 90.56 | 372 | 17.7 | 0.049 | 0.375 | 1.178 | 2690 | 1712 | 0.003 | 7.171 | 2.5582 | 159.2 |
| | 23.7 | 40 | 38.4 | 14.7 | 0.12 | 13.32 | 1055 | 1.355 | 377 | 89.59 | 371 | 17.5 | 0.049 | 0.375 | 1.177 | 2690 | 1712 | 0.003 | 7.161 | 2.5563 | 159.2 |
| | 23.8 | 40.1 | 38.5 | 14.7 | 0.12 | 13.32 | 1055 | 1.353 | 376 | 89.59 | 370 | 17.5 | 0.049 | 0.374 | 1.175 | 2690 | 1712 | 0.003 | 7.138 | 2.5525 | 159.2 |
| | | | | | | | | | | 89.92 | 371 | 17.6 | 0.049 | 0.374 | 1.176 | 2690 | 1712 | 0.003 | 7.156 | | |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1055 Hz | 0.1823 | 14.157 | 6.406 | 6.406 | 0.8034 | 16.828 | 0.1687 | 0.5749 | 0.002 | 0.5992 |
| L = 73 cm | 0.1801 | 14.148 | 6.2549 | 6.2549 | 0.7973 | 16.706 | 0.1687 | 0.5739 | 0.002 | 0.5982 |
| PR ~ 2.2 | 0.1801 | 14.148 | 6.2549 | 6.2549 | 0.7973 | 16.706 | 0.1687 | 0.5734 | 0.002 | 0.5977 |
| | | | | | | 16.747 | | | | 0.5984 |
| | 0.1591 | 12.61 | 4.5251 | 4.5251 | 0.7763 | 14.163 | 0.1687 | 0.5719 | 0.002 | 0.5963 |
| | 0.16 | 12.609 | 4.563 | 4.563 | 0.776 | 14.187 | 0.1687 | 0.5749 | 0.002 | 0.5991 |
| | 0.1589 | 12.613 | 4.5262 | 4.5262 | 0.7788 | 14.167 | 0.1687 | 0.5739 | 0.002 | 0.5982 |
| | | | | | | 14.172 | | | | 0.5979 |
| | 0.1441 | 10.491 | 3.4182 | 3.4182 | 0.8468 | 11.583 | 0.1687 | 0.5744 | 0.002 | 0.5987 |
| | 0.1431 | 10.496 | 3.3986 | 3.3986 | 0.8516 | 11.576 | 0.1685 | 0.5749 | 0.002 | 0.5991 |
| | 0.143 | 10.49 | 3.3757 | 3.3757 | 0.8458 | 11.557 | 0.1685 | 0.5749 | 0.002 | 0.5991 |
| | | | | | | 11.572 | | | | 0.599 |
| f ~ 1055 Hz | 0.1778 | 14.247 | 6.6021 | 6.6021 | 0.8659 | 17.057 | 0.1689 | 0.5284 | 0.002 | 0.5548 |
| L = 73 cm | 0.1767 | 14.261 | 6.6085 | 6.6085 | 0.8755 | 17.074 | 0.1689 | 0.5263 | 0.002 | 0.5528 |
| PR ~ 2.4 | 0.1757 | 14.255 | 6.5271 | 6.5271 | 0.8714 | 17.006 | 0.1689 | 0.5272 | 0.002 | 0.5536 |
| | | | | | | 17.046 | | | | 0.5537 |
| | 0.1602 | 11.589 | 4.8409 | 4.8409 | 0.9362 | 13.494 | 0.1687 | 0.531 | 0.002 | 0.5571 |
| | 0.1565 | 11.591 | 4.6778 | 4.6778 | 0.9382 | 13.38 | 0.1687 | 0.5301 | 0.002 | 0.5563 |
| | 0.1546 | 11.571 | 4.5165 | 4.5165 | 0.9208 | 13.25 | 0.1687 | 0.5284 | 0.002 | 0.5547 |
| | | | | | | 13.375 | | | | 0.5561 |
| | 0.1409 | 9.785 | 3.398 | 3.398 | 0.9724 | 10.946 | 0.1686 | 0.5263 | 0.002 | 0.5527 |
| | 0.1404 | 9.7842 | 3.377 | 3.377 | 0.9716 | 10.932 | 0.1686 | 0.5263 | 0.002 | 0.5527 |
| | 0.1398 | 9.7772 | 3.3339 | 3.3339 | 0.9643 | 10.898 | 0.1685 | 0.5259 | 0.002 | 0.5522 |
| | | | | | | 10.925 | | | | 0.5525 |
| f ~ 1055 Hz | 0.1765 | 14.326 | 6.8875 | 6.8875 | 0.9206 | 17.349 | 0.1686 | 0.4842 | 0.002 | 0.5127 |
| L = 73 cm | 0.175 | 14.325 | 6.8022 | 6.8022 | 0.9202 | 17.281 | 0.1686 | 0.4846 | 0.002 | 0.5131 |
| PR ~ 2.6 | 0.1746 | 14.29 | 6.622 | 6.622 | 0.8958 | 17.11 | 0.1686 | 0.4849 | 0.002 | 0.5134 |
| | | | | | | 17.247 | | | | 0.5131 |
| | 0.1535 | 11.623 | 4.6511 | 4.6511 | 0.9653 | 13.391 | 0.1685 | 0.4853 | 0.002 | 0.5137 |
| | 0.1517 | 11.59 | 4.4508 | 4.4508 | 0.9369 | 13.223 | 0.1685 | 0.4853 | 0.002 | 0.5137 |
| | 0.1517 | 11.59 | 4.4508 | 4.4508 | 0.9369 | 13.223 | 0.1685 | 0.4857 | 0.002 | 0.5141 |
| | | | | | | 13.279 | | | | 0.5138 |
| | 0.1383 | 9.825 | 3.4119 | 3.4119 | 1.0132 | 10.994 | 0.1684 | 0.4867 | 0.002 | 0.515 |
| | 0.139 | 9.8144 | 3.4082 | 3.4082 | 1.0024 | 10.981 | 0.1684 | 0.4871 | 0.002 | 0.5154 |
| | 0.139 | 9.8144 | 3.4082 | 3.4082 | 1.0024 | 10.981 | 0.1684 | 0.4878 | 0.002 | 0.5161 |
| | | | | | | 10.985 | | | | 0.5155 |

| Experiment Information | T a (C) | T to (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr / Rs*Rs | Rs / Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 900 Hz | 23 | 30.7 | 30.2 | 7.2 | 0.07 | 7.07 | 897 | 0.502 | 60.8 | 56.56 | 60.6 | 11.1 | 0.041 | 0.163 | 0.512 | 2287 | 1456 | 0.054 | 1.268 | 0.9471 | 150.6 |
| L = 67 cm | 23.1 | 31 | 30.5 | 7.39 | 0.07 | 7.15 | 897 | 0.502 | 60.8 | 55.69 | 60.6 | 10.9 | 0.041 | 0.163 | 0.512 | 2287 | 1456 | 0.055 | 1.268 | 0.9471 | 150.6 |
| PR ~ 0.9 | 23.1 | 31 | 30.5 | 7.39 | 0.07 | 7.21 | 897 | 0.502 | 60.8 | 56.19 | 60.6 | 11 | 0.041 | 0.163 | 0.512 | 2287 | 1456 | 0.055 | 1.268 | 0.9471 | 150.6 |
|  |  |  |  |  |  |  |  |  |  | 56.15 | 60.6 | 11 | 0.041 | 0.163 | 0.512 | 2287 | 1456 | 0.055 | 1.268 |  |  |
|  | 23.2 | 35.3 | 34.6 | 11.4 | 0.08 | 9.04 | 897 | 0.503 | 61 | 52.34 | 60.9 | 10.2 | 0.041 | 0.163 | 0.513 | 2287 | 1456 | 0.084 | 1.273 | 0.9489 | 150.6 |
|  | 23.2 | 35.6 | 34.9 | 11.7 | 0.08 | 9.16 | 897 | 0.502 | 60.8 | 51.71 | 60.6 | 10.1 | 0.041 | 0.163 | 0.512 | 2287 | 1456 | 0.087 | 1.268 | 0.9471 | 150.6 |
|  | 23.2 | 35.6 | 34.8 | 11.6 | 0.08 | 9.24 | 897 | 0.502 | 60.8 | 52.19 | 60.6 | 10.2 | 0.041 | 0.163 | 0.512 | 2287 | 1456 | 0.087 | 1.268 | 0.9471 | 150.6 |
|  |  |  |  |  |  |  |  |  |  | 52.08 | 60.7 | 10.2 | 0.041 | 0.163 | 0.513 | 2287 | 1456 | 0.086 | 1.27 |  |  |
|  | 23.3 | 39 | 38.1 | 14.8 | 0.09 | 10.28 | 897 | 0.502 | 60.8 | 51.56 | 60.6 | 10.1 | 0.041 | 0.163 | 0.512 | 2287 | 1456 | 0.109 | 1.268 | 0.9471 | 150.6 |
|  | 23.4 | 38.9 | 38 | 14.6 | 0.09 | 10.08 | 897 | 0.503 | 61.1 | 51.18 | 60.9 | 10 | 0.041 | 0.163 | 0.513 | 2287 | 1456 | 0.107 | 1.273 | 0.9489 | 150.6 |
|  | 23.4 | 38.9 | 38 | 14.6 | 0.09 | 10.12 | 897 | 0.503 | 61.1 | 51.4 | 60.9 | 10 | 0.041 | 0.163 | 0.513 | 2287 | 1456 | 0.107 | 1.273 | 0.9489 | 150.6 |
|  |  |  |  |  |  |  |  |  |  | 51.38 | 60.8 | 10 | 0.041 | 0.163 | 0.513 | 2287 | 1456 | 0.108 | 1.272 |  |  |
| f ~ 900 Hz | 23.4 | 31.3 | 30.8 | 7.39 | 0.07 | 7.14 | 897 | 0.601 | 87.2 | 55.61 | 86.9 | 10.9 | 0.041 | 0.195 | 0.614 | 2287 | 1456 | 0.027 | 1.818 | 1.1338 | 152.2 |
| L = 67 cm | 23.4 | 31.5 | 31 | 7.58 | 0.07 | 7.23 | 897 | 0.601 | 87.2 | 54.87 | 86.9 | 10.7 | 0.041 | 0.195 | 0.614 | 2287 | 1456 | 0.027 | 1.818 | 1.1338 | 152.2 |
| PR ~ 1.1 | 23.4 | 31.6 | 31.1 | 7.68 | 0.07 | 7.26 | 897 | 0.601 | 87.2 | 54.4 | 86.9 | 10.6 | 0.041 | 0.195 | 0.614 | 2287 | 1456 | 0.028 | 1.818 | 1.1338 | 152.2 |
|  |  |  |  |  |  |  |  |  |  | 54.96 | 86.9 | 10.7 | 0.041 | 0.195 | 0.614 | 2287 | 1456 | 0.027 | 1.818 |  |  |
|  | 23.4 | 35.6 | 34.9 | 11.5 | 0.08 | 9.08 | 897 | 0.601 | 87.2 | 52.12 | 86.9 | 10.2 | 0.041 | 0.195 | 0.614 | 2287 | 1456 | 0.041 | 1.818 | 1.1338 | 152.2 |
|  | 23.5 | 35.7 | 35 | 11.5 | 0.08 | 9.08 | 897 | 0.601 | 87.2 | 52.12 | 86.9 | 10.2 | 0.041 | 0.195 | 0.614 | 2287 | 1456 | 0.041 | 1.818 | 1.1338 | 152.2 |
|  | 23.5 | 35.7 | 35 | 11.5 | 0.08 | 9.14 | 897 | 0.602 | 87.5 | 52.49 | 87.2 | 10.3 | 0.041 | 0.196 | 0.615 | 2287 | 1456 | 0.041 | 1.824 | 1.1357 | 152.2 |
|  |  |  |  |  |  |  |  |  |  | 52.25 | 87 | 10.2 | 0.041 | 0.195 | 0.614 | 2287 | 1456 | 0.041 | 1.82 |  |  |
|  | 23.5 | 38.8 | 37.9 | 14.4 | 0.09 | 10.21 | 897 | 0.602 | 87.5 | 52.61 | 87.2 | 10.3 | 0.041 | 0.196 | 0.615 | 2287 | 1456 | 0.051 | 1.824 | 1.1357 | 152.2 |
|  | 23.5 | 38.7 | 37.8 | 14.3 | 0.09 | 10.21 | 897 | 0.602 | 87.5 | 52.98 | 87.2 | 10.4 | 0.041 | 0.196 | 0.615 | 2287 | 1456 | 0.051 | 1.824 | 1.1357 | 152.2 |
|  | 23.5 | 38.9 | 38 | 14.5 | 0.09 | 10.32 | 897 | 0.602 | 87.5 | 52.84 | 87.2 | 10.3 | 0.041 | 0.196 | 0.615 | 2287 | 1456 | 0.051 | 1.824 | 1.1357 | 152.2 |
|  |  |  |  |  |  |  |  |  |  | 52.81 | 87.2 | 10.3 | 0.041 | 0.196 | 0.615 | 2287 | 1456 | 0.051 | 1.824 |  |  |
| f ~ 900 Hz | 23.3 | 31.7 | 31.1 | 7.84 | 0.07 | 7.82 | 897 | 0.704 | 120 | 57.4 | 119 | 11.2 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.015 | 2.494 | 1.3282 | 153.6 |
| L = 67 cm | 23.3 | 31.9 | 31.3 | 8.04 | 0.07 | 7.82 | 897 | 0.705 | 120 | 55.97 | 120 | 10.9 | 0.041 | 0.229 | 0.72 | 2287 | 1456 | 0.015 | 2.501 | 1.33 | 153.6 |
| PR ~ 1.3 | 23.3 | 32 | 31.4 | 8.14 | 0.07 | 7.9 | 897 | 0.704 | 120 | 55.89 | 119 | 10.9 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.016 | 2.494 | 1.3282 | 153.6 |
|  |  |  |  |  |  |  |  |  |  | 56.42 | 119 | 11 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.015 | 2.497 |  |  |
|  | 23.4 | 35.9 | 35 | 11.6 | 0.09 | 9.51 | 897 | 0.704 | 120 | 60.53 | 119 | 11.8 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.022 | 2.495 | 1.3282 | 153.6 |
|  | 23.4 | 36 | 35.1 | 11.7 | 0.09 | 9.51 | 897 | 0.704 | 120 | 60.01 | 119 | 11.7 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.022 | 2.495 | 1.3282 | 153.6 |
|  | 23.5 | 36.1 | 35.2 | 11.7 | 0.09 | 9.61 | 897 | 0.704 | 120 | 60.69 | 119 | 11.9 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.022 | 2.495 | 1.3282 | 153.6 |
|  |  |  |  |  |  |  |  |  |  | 60.41 | 119 | 11.8 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.022 | 2.495 |  |  |
|  | 23.7 | 39.9 | 38.8 | 15.1 | 0.1 | 10.91 | 897 | 0.704 | 120 | 59.46 | 119 | 11.6 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.028 | 2.495 | 1.3282 | 153.6 |
|  | 23.7 | 40 | 38.9 | 15.2 | 0.1 | 10.91 | 897 | 0.704 | 120 | 59.07 | 119 | 11.5 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.029 | 2.495 | 1.3282 | 153.6 |
|  | 23.7 | 40.1 | 39 | 15.3 | 0.1 | 10.98 | 897 | 0.704 | 120 | 59.09 | 119 | 11.5 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.029 | 2.495 | 1.3282 | 153.6 |
|  |  |  |  |  |  |  |  |  |  | 59.21 | 119 | 11.6 | 0.041 | 0.229 | 0.719 | 2287 | 1456 | 0.029 | 2.495 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 900 Hz | 0.2049 | 15.822 | 6.9488 | 6.9488 | 0.6328 | 18.638 | 0.1688 | 1.3147 | 0.002 | 1.3255 |
| L = 67 cm | 0.203 | 15.807 | 6.7661 | 6.7661 | 0.6231 | 18.489 | 0.1688 | 1.3147 | 0.002 | 1.3255 |
| PR ~ 0.9 | 0.2018 | 15.816 | 6.77 | 6.77 | 0.6287 | 18.5 | 0.1688 | 1.3147 | 0.002 | 1.3255 |
|  |  |  |  |  |  | 18.542 |  |  |  | 1.3255 |
|  | 0.171 | 13.843 | 4.4003 | 4.4003 | 0.5855 | 15.19 | 0.1687 | 1.3121 | 0.002 | 1.3229 |
|  | 0.1694 | 13.833 | 4.2907 | 4.2907 | 0.5785 | 15.118 | 0.1687 | 1.3147 | 0.002 | 1.3255 |
|  | 0.1685 | 13.841 | 4.2931 | 4.2931 | 0.5839 | 15.126 | 0.1687 | 1.3147 | 0.002 | 1.3255 |
|  |  |  |  |  |  | 15.145 |  |  |  | 1.3247 |
|  | 0.1567 | 12.353 | 3.3882 | 3.3882 | 0.5768 | 13.263 | 0.1687 | 1.3147 | 0.002 | 1.3255 |
|  | 0.1587 | 12.348 | 3.4305 | 3.4305 | 0.5726 | 13.28 | 0.1686 | 1.3121 | 0.002 | 1.3229 |
|  | 0.1583 | 12.351 | 3.4313 | 3.4313 | 0.575 | 13.283 | 0.1686 | 1.3121 | 0.002 | 1.3229 |
|  |  |  |  |  |  | 13.276 |  |  |  | 1.3238 |
| f ~ 900 Hz | 0.2032 | 15.805 | 6.7654 | 6.7654 | 0.6222 | 18.487 | 0.1686 | 1.0982 | 0.002 | 1.111 |
| L = 67 cm | 0.2011 | 15.792 | 6.5927 | 6.5927 | 0.6139 | 18.35 | 0.1686 | 1.0982 | 0.002 | 1.111 |
| PR ~ 1.1 | 0.2004 | 15.783 | 6.5088 | 6.5088 | 0.6086 | 18.282 | 0.1686 | 1.0982 | 0.002 | 1.111 |
|  |  |  |  |  |  | 18.373 |  |  |  | 1.111 |
|  | 0.1705 | 13.84 | 4.3632 | 4.3632 | 0.5832 | 15.165 | 0.1686 | 1.0982 | 0.002 | 1.111 |
|  | 0.1705 | 13.84 | 4.3632 | 4.3632 | 0.5832 | 15.165 | 0.1685 | 1.0982 | 0.002 | 1.111 |
|  | 0.1698 | 13.846 | 4.365 | 4.365 | 0.5873 | 15.172 | 0.1685 | 1.0963 | 0.002 | 1.1092 |
|  |  |  |  |  |  | 15.168 |  |  |  | 1.1104 |
|  | 0.1576 | 12.368 | 3.4811 | 3.4811 | 0.5886 | 13.326 | 0.1685 | 1.0963 | 0.002 | 1.1092 |
|  | 0.1577 | 12.374 | 3.5055 | 3.5055 | 0.5927 | 13.344 | 0.1685 | 1.0963 | 0.002 | 1.1092 |
|  | 0.1565 | 12.372 | 3.4594 | 3.4594 | 0.5912 | 13.318 | 0.1685 | 1.0963 | 0.002 | 1.1092 |
|  |  |  |  |  |  | 13.329 |  |  |  | 1.1092 |
| f ~ 900 Hz | 0.1905 | 15.838 | 6.3759 | 6.3759 | 0.6422 | 18.237 | 0.1687 | 0.9375 | 0.002 | 0.9526 |
| L = 67 cm | 0.1902 | 15.812 | 6.2174 | 6.2174 | 0.6262 | 18.104 | 0.1687 | 0.9362 | 0.002 | 0.9512 |
| PR ~ 1.3 | 0.1888 | 15.81 | 6.1453 | 6.1453 | 0.6253 | 18.053 | 0.1687 | 0.9375 | 0.002 | 0.9526 |
|  |  |  |  |  |  | 18.131 |  |  |  | 0.9521 |
|  | 0.1668 | 12.482 | 4.3001 | 4.3001 | 0.6772 | 13.902 | 0.1686 | 0.9375 | 0.002 | 0.9525 |
|  | 0.1667 | 12.475 | 4.2635 | 4.2635 | 0.6714 | 13.873 | 0.1686 | 0.9375 | 0.002 | 0.9525 |
|  | 0.1656 | 12.485 | 4.2668 | 4.2668 | 0.679 | 13.884 | 0.1685 | 0.9375 | 0.002 | 0.9525 |
|  |  |  |  |  |  | 13.886 |  |  |  | 0.9525 |
|  | 0.1521 | 11.274 | 3.3139 | 3.3139 | 0.6652 | 12.228 | 0.1684 | 0.9375 | 0.002 | 0.9525 |
|  | 0.152 | 11.269 | 3.2921 | 3.2921 | 0.6609 | 12.212 | 0.1684 | 0.9375 | 0.002 | 0.9525 |
|  | 0.1514 | 11.269 | 3.2721 | 3.2721 | 0.6611 | 12.201 | 0.1684 | 0.9375 | 0.002 | 0.9525 |
|  |  |  |  |  |  | 12.214 |  |  |  | 0.9525 |

| Experiment Information | T a (C) | T to (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 900 Hz | 23.5 | 32.5 | 31.9 | 8.43 | 0.07 | 8 | 897 | 0.801 | 155 | 54.63 | 154 | 10.7 | 0.041 | 0.26 | 0.818 | 2287 | 1456 | 0.01 | 3.23 | 1.5111 | 154.7 |
| L = 67 cm | 23.5 | 32.6 | 32 | 8.53 | 0.07 | 8 | 897 | 0.801 | 155 | 53.99 | 154 | 10.5 | 0.041 | 0.26 | 0.818 | 2287 | 1456 | 0.01 | 3.23 | 1.5111 | 154.7 |
| PR ~ 1.5 | 23.5 | 32.7 | 32.1 | 8.62 | 0.07 | 8.12 | 897 | 0.801 | 155 | 54.22 | 154 | 10.6 | 0.041 | 0.26 | 0.818 | 2287 | 1456 | 0.01 | 3.23 | 1.5111 | 154.7 |
| | | | | | | | | | | 54.28 | 154 | 10.6 | 0.041 | 0.26 | 0.818 | 2287 | 1456 | 0.01 | 3.23 | | |
| | 23.5 | 36 | 35.1 | 11.6 | 0.09 | 9.79 | 897 | 0.801 | 155 | 62.45 | 154 | 12.2 | 0.041 | 0.26 | 0.818 | 2287 | 1456 | 0.013 | 3.23 | 1.5111 | 154.7 |
| | 23.6 | 36.1 | 35.2 | 11.6 | 0.09 | 9.79 | 897 | 0.801 | 155 | 62.45 | 154 | 12.2 | 0.041 | 0.26 | 0.818 | 2287 | 1456 | 0.013 | 3.23 | 1.5111 | 154.7 |
| | 23.6 | 36 | 35.1 | 11.5 | 0.09 | 9.85 | 897 | 0.801 | 155 | 63.41 | 154 | 12.4 | 0.041 | 0.26 | 0.818 | 2287 | 1456 | 0.013 | 3.23 | 1.5111 | 154.7 |
| | | | | | | | | | | 62.77 | 154 | 12.3 | 0.041 | 0.26 | 0.818 | 2287 | 1456 | 0.013 | 3.23 | | |
| | 23.6 | 39.5 | 38.4 | 14.8 | 0.1 | 11.03 | 897 | 0.8 | 155 | 61.38 | 154 | 12 | 0.041 | 0.26 | 0.817 | 2287 | 1456 | 0.017 | 3.222 | 1.5093 | 154.7 |
| | 23.7 | 39.4 | 38.3 | 14.6 | 0.1 | 11.03 | 897 | 0.8 | 155 | 62.23 | 154 | 12.2 | 0.041 | 0.26 | 0.817 | 2287 | 1456 | 0.016 | 3.222 | 1.5093 | 154.7 |
| | 23.7 | 39.5 | 38.4 | 14.7 | 0.1 | 11.14 | 897 | 0.8 | 155 | 62.47 | 154 | 12.2 | 0.041 | 0.26 | 0.817 | 2287 | 1456 | 0.017 | 3.222 | 1.5093 | 154.7 |
| | | | | | | | | | | 62.03 | 154 | 12.1 | 0.041 | 0.26 | 0.817 | 2287 | 1456 | 0.017 | 3.222 | | |
| f ~ 585 Hz | 22.2 | 29.8 | 28.7 | 6.53 | 0.1 | 10.51 | 585 | 1.252 | 578 | 132.4 | 576 | 25.9 | 0.027 | 0.623 | 1.956 | 1491 | 949.5 | 6E-04 | 14.9 | 2.362 | 158.6 |
| L = 73 cm | 22.3 | 30.4 | 29.3 | 7.01 | 0.1 | 10.71 | 586 | 1.253 | 578 | 125.7 | 576 | 24.6 | 0.027 | 0.622 | 1.954 | 1494 | 951.1 | 6E-04 | 14.92 | 2.3639 | 158.6 |
| PR ~ 2.3 | 22.3 | 30.5 | 29.4 | 7.11 | 0.1 | 10.74 | 586 | 1.254 | 579 | 124.3 | 577 | 24.3 | 0.027 | 0.623 | 1.956 | 1494 | 951.1 | 6E-04 | 14.94 | 2.3658 | 158.6 |
| | | | | | | | | | | 127.4 | 576 | 24.9 | 0.027 | 0.622 | 1.955 | 1493 | 950.6 | 6E-04 | 14.92 | | |
| | 22.5 | 34.4 | 32.8 | 10.3 | 0.12 | 12.87 | 586 | 1.255 | 580 | 123 | 579 | 24 | 0.027 | 0.623 | 1.958 | 1494 | 951.1 | 9E-04 | 14.97 | 2.3677 | 158.6 |
| | 22.5 | 34.4 | 32.8 | 10.3 | 0.12 | 12.95 | 586 | 1.256 | 581 | 123.9 | 579 | 24.2 | 0.027 | 0.624 | 1.96 | 1494 | 951.1 | 9E-04 | 14.99 | 2.3695 | 158.6 |
| | 22.6 | 34.4 | 32.8 | 10.2 | 0.12 | 12.91 | 586 | 1.255 | 581 | 124.6 | 579 | 24.4 | 0.027 | 0.623 | 1.958 | 1494 | 951.1 | 9E-04 | 14.97 | 2.3677 | 158.6 |
| | | | | | | | | | | 123.8 | 579 | 24.2 | 0.027 | 0.623 | 1.959 | 1494 | 951.1 | 9E-04 | 14.98 | | |
| | 22.7 | 37.9 | 35.9 | 13.2 | 0.13 | 14.75 | 586 | 1.255 | 581 | 119 | 579 | 23.3 | 0.027 | 0.623 | 1.959 | 1494 | 951.1 | 0.001 | 14.97 | 2.3677 | 158.6 |
| | 22.9 | 38.8 | 36.8 | 13.9 | 0.13 | 15.04 | 586 | 1.252 | 578 | 115.6 | 576 | 22.6 | 0.027 | 0.622 | 1.955 | 1494 | 951.1 | 0.001 | 14.91 | 2.362 | 158.6 |
| | 22.9 | 38.7 | 36.7 | 13.8 | 0.13 | 14.96 | 586 | 1.251 | 577 | 115.7 | 575 | 22.6 | 0.027 | 0.622 | 1.953 | 1494 | 951.1 | 0.001 | 14.88 | 2.3601 | 158.5 |
| | | | | | | | | | | 116.8 | 577 | 22.8 | 0.027 | 0.622 | 1.956 | 1494 | 951.1 | 0.001 | 14.92 | | |
| f ~ 585 Hz | 22.9 | 30.8 | 29.7 | 6.77 | 0.1 | 11.08 | 586 | 1.359 | 681 | 134.6 | 679 | 26.3 | 0.027 | 0.675 | 2.122 | 1494 | 951.1 | 4E-04 | 17.57 | 2.5639 | 159.3 |
| L = 73 cm | 23 | 30.9 | 29.8 | 6.76 | 0.1 | 11.2 | 586 | 1.359 | 682 | 136.3 | 679 | 26.6 | 0.027 | 0.675 | 2.122 | 1494 | 951.1 | 4E-04 | 17.57 | 2.5639 | 159.3 |
| PR ~ 2.6 | 23 | 31 | 29.8 | 6.85 | 0.1 | 11.29 | 586 | 1.358 | 681 | 135.5 | 678 | 26.5 | 0.027 | 0.675 | 2.121 | 1494 | 951.1 | 4E-04 | 17.54 | 2.562 | 159.3 |
| | | | | | | | | | | 135.5 | 679 | 26.5 | 0.027 | 0.675 | 2.121 | 1494 | 951.1 | 4E-04 | 17.56 | | |
| | 23.1 | 34.2 | 32.6 | 9.47 | 0.12 | 13.35 | 586 | 1.359 | 682 | 139.1 | 679 | 27.2 | 0.027 | 0.676 | 2.122 | 1494 | 951.1 | 6E-04 | 17.57 | 2.5639 | 159.3 |
| | 23.2 | 34.8 | 33.1 | 9.94 | 0.12 | 13.59 | 586 | 1.358 | 681 | 134.9 | 678 | 26.4 | 0.027 | 0.675 | 2.121 | 1494 | 951.1 | 6E-04 | 17.55 | 2.562 | 159.3 |
| | 23.3 | 35.2 | 33.5 | 10.2 | 0.12 | 13.89 | 587 | 1.354 | 676 | 134.4 | 674 | 26.3 | 0.027 | 0.672 | 2.112 | 1497 | 952.7 | 6E-04 | 17.43 | 2.5544 | 159.2 |
| | | | | | | | | | | 136.2 | 677 | 26.6 | 0.027 | 0.674 | 2.118 | 1495 | 951.6 | 6E-04 | 17.52 | | |
| | 23.3 | 39 | 36.7 | 13.4 | 0.14 | 16.16 | 587 | 1.356 | 678 | 138.9 | 676 | 27.1 | 0.027 | 0.673 | 2.115 | 1497 | 952.7 | 8E-04 | 17.48 | 2.5582 | 159.2 |
| | 23.4 | 40.5 | 38 | 14.6 | 0.15 | 16.65 | 587 | 1.358 | 680 | 141.1 | 678 | 27.6 | 0.027 | 0.674 | 2.118 | 1497 | 952.7 | 9E-04 | 17.54 | 2.562 | 159.3 |
| | 23.5 | 39.6 | 37.3 | 13.8 | 0.14 | 16.21 | 587 | 1.358 | 681 | 135.4 | 679 | 26.4 | 0.027 | 0.675 | 2.12 | 1496 | 952.3 | 8E-04 | 17.55 | 2.562 | 159.3 |
| | | | | | | | | | | 138.5 | 678 | 27.1 | 0.027 | 0.674 | 2.118 | 1496 | 952.6 | 8E-04 | 17.52 | | |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 900 Hz | 0.1869 | 15.787 | 5.9318 | 5.9318 | 0.6112 | 17.889 | 0.1685 | 0.824 | 0.002 | 0.841 |
| L = 67 cm | 0.1867 | 15.775 | 5.8622 | 5.8622 | 0.604 | 17.832 | 0.1685 | 0.824 | 0.002 | 0.841 |
| PR ~ 1.5 | 0.1848 | 15.779 | 5.8001 | 5.8001 | 0.6066 | 17.795 | 0.1685 | 0.824 | 0.002 | 0.841 |
| | | | | | | 17.839 | | | | 0.841 |
| | 0.1639 | 12.51 | 4.3097 | 4.3097 | 0.6987 | 13.934 | 0.1685 | 0.824 | 0.002 | 0.841 |
| | 0.1639 | 12.51 | 4.3097 | 4.3097 | 0.6987 | 13.934 | 0.1685 | 0.824 | 0.002 | 0.841 |
| | 0.1634 | 12.524 | 4.3492 | 4.3492 | 0.7094 | 13.972 | 0.1685 | 0.824 | 0.002 | 0.841 |
| | | | | | | 13.947 | | | | 0.841 |
| | 0.1514 | 11.299 | 3.3839 | 3.3839 | 0.6868 | 12.291 | 0.1685 | 0.825 | 0.002 | 0.842 |
| | 0.1515 | 11.31 | 3.4304 | 3.4304 | 0.6962 | 12.327 | 0.1684 | 0.825 | 0.002 | 0.842 |
| | 0.1506 | 11.313 | 3.4096 | 3.4096 | 0.6989 | 12.319 | 0.1684 | 0.825 | 0.002 | 0.842 |
| | | | | | | 12.312 | | | | 0.842 |
| f ~ 585 Hz | 0.169 | 12.223 | 7.6586 | 7.6586 | 1.481 | 16.399 | 0.1693 | 0.5272 | 0.002 | 0.5537 |
| L = 73 cm | 0.1657 | 12.136 | 7.1344 | 7.1344 | 1.4059 | 15.845 | 0.1692 | 0.5267 | 0.002 | 0.5533 |
| PR ~ 2.3 | 0.1652 | 12.118 | 7.0371 | 7.0371 | 1.3906 | 15.743 | 0.1692 | 0.5263 | 0.002 | 0.5529 |
| | | | | | | 15.996 | | | | 0.5533 |
| | 0.1472 | 10.18 | 4.8423 | 4.8423 | 1.376 | 12.347 | 0.1691 | 0.5259 | 0.002 | 0.5524 |
| | 0.1468 | 10.19 | 4.8469 | 4.8469 | 1.3859 | 12.36 | 0.1691 | 0.5255 | 0.002 | 0.552 |
| | 0.1472 | 10.198 | 4.892 | 4.892 | 1.3945 | 12.403 | 0.1691 | 0.5259 | 0.002 | 0.5524 |
| | | | | | | 12.37 | | | | 0.5523 |
| | 0.1352 | 9.4013 | 3.7749 | 3.7749 | 1.3319 | 10.894 | 0.169 | 0.5259 | 0.002 | 0.5524 |
| | 0.1332 | 9.3664 | 3.5953 | 3.5953 | 1.2934 | 10.737 | 0.1689 | 0.5272 | 0.002 | 0.5536 |
| | 0.1336 | 9.3677 | 3.6186 | 3.6186 | 1.2949 | 10.753 | 0.1689 | 0.5276 | 0.002 | 0.554 |
| | | | | | | 10.795 | | | | 0.5533 |
| f ~ 585 Hz | 0.1636 | 12.252 | 7.3849 | 7.3849 | 1.5056 | 16.17 | 0.1689 | 0.4857 | 0.002 | 0.5142 |
| L = 73 cm | 0.1628 | 12.274 | 7.3983 | 7.3983 | 1.5246 | 16.201 | 0.1688 | 0.4857 | 0.002 | 0.5142 |
| PR ~ 2.6 | 0.1619 | 12.264 | 7.3002 | 7.3002 | 1.5165 | 16.104 | 0.1688 | 0.486 | 0.002 | 0.5145 |
| | | | | | | 16.158 | | | | 0.5143 |
| | 0.1465 | 10.357 | 5.2815 | 5.2815 | 1.5568 | 12.865 | 0.1688 | 0.4857 | 0.002 | 0.5141 |
| | 0.1443 | 10.311 | 5.0314 | 5.0314 | 1.5098 | 12.619 | 0.1687 | 0.486 | 0.002 | 0.5145 |
| | 0.1423 | 10.305 | 4.9015 | 4.9015 | 1.5033 | 12.511 | 0.1687 | 0.4874 | 0.002 | 0.5158 |
| | | | | | | 12.665 | | | | 0.5148 |
| | 0.1311 | 8.9588 | 3.7331 | 3.7331 | 1.554 | 10.515 | 0.1687 | 0.4867 | 0.002 | 0.5151 |
| | 0.1293 | 8.4203 | 3.4355 | 3.4355 | 1.5787 | 9.8496 | 0.1686 | 0.486 | 0.002 | 0.5144 |
| | 0.1304 | 8.9253 | 3.6267 | 3.6267 | 1.5144 | 10.406 | 0.1685 | 0.486 | 0.002 | 0.5144 |
| | | | | | | 10.257 | | | | 0.5147 |

| Experiment Information | T a (C) | T b (C) | Ts (C) | Ts-Ta (C) | Curr (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 585 Hz | 23.4 | 31.6 | 30.3 | 6.88 | 0.11 | [illegible] | 587 | 1.452 | 778 | 155.2 | 776 | 30.3 | 0.027 | 0.721 | 2.265 | 1497 | 952.7 | 3E-04 | 20.05 | 2.7393 | 159.8 |
| L = 73 cm | 23.3 | 31.7 | 30.4 | 7.06 | 0.11 | 11.92 | 587 | 1.453 | 779 | 152.6 | 777 | 29.8 | 0.027 | 0.721 | 2.266 | 1497 | 952.7 | 3E-04 | 20.07 | 2.7412 | 159.8 |
| PR ~ 2.7 | 23.4 | 31.6 | 30.3 | 6.87 | 0.11 | 11.86 | 587 | 1.45 | 776 | 156.2 | 773 | 30.5 | 0.027 | 0.72 | 2.262 | 1497 | 952.7 | 3E-04 | 19.99 | 2.7355 | 159.8 |
| | | | | | | | | | | 154.7 | 775 | 30.2 | 0.027 | 0.721 | 2.264 | 1497 | 952.7 | 3E-04 | 20.04 | | |
| | 23.3 | 35.3 | 33.4 | 10.1 | 0.13 | 14.44 | 587 | 1.454 | 780 | 153 | 778 | 29.9 | 0.027 | 0.722 | 2.268 | 1497 | 952.7 | 5E-04 | 20.1 | 2.7431 | 159.9 |
| | 23.3 | 35.5 | 33.6 | 10.3 | 0.13 | 14.66 | 587 | 1.455 | 781 | 152.8 | 779 | 29.9 | 0.027 | 0.722 | 2.269 | 1497 | 952.7 | 5E-04 | 20.13 | 2.745 | 159.9 |
| | 23.3 | 35.5 | 33.6 | 10.3 | 0.13 | 14.59 | 587 | 1.452 | 778 | 151.9 | 775 | 29.7 | 0.027 | 0.721 | 2.265 | 1497 | 952.7 | 5E-04 | 20.05 | 2.7393 | 159.8 |
| | | | | | | | | | | 152.6 | 777 | 29.8 | 0.027 | 0.722 | 2.267 | 1497 | 952.7 | 5E-04 | 20.09 | | |
| | 23.4 | 39.4 | 36.8 | 13.4 | 0.15 | 16.8 | 587 | 1.452 | 778 | 154.3 | 776 | 30.1 | 0.027 | 0.721 | 2.265 | 1497 | 952.7 | 6E-04 | 20.05 | 2.7393 | 159.8 |
| | 23.6 | 39.8 | 37.2 | 13.6 | 0.15 | 16.96 | 587 | 1.451 | 777 | 153.7 | 775 | 30 | 0.027 | 0.721 | 2.264 | 1497 | 952.7 | 6E-04 | 20.03 | 2.7374 | 159.8 |
| | 23.6 | 39.8 | 37.2 | 13.6 | 0.15 | 16.96 | 587 | 1.45 | 776 | 153.7 | 774 | 30 | 0.027 | 0.72 | 2.263 | 1497 | 952.7 | 6E-04 | 20 | 2.7355 | 159.8 |
| | | | | | | | | | | 153.9 | 775 | 30.1 | 0.027 | 0.721 | 2.264 | 1497 | 952.7 | 6E-04 | 20.03 | | |
| f ~ 585 Hz | 21.7 | 30 | 28.6 | 6.9 | 0.11 | 12.51 | 586 | 1.554 | 887 | 164.1 | 886 | 32.1 | 0.027 | 0.771 | 2.421 | 1494 | 951.1 | 3E-04 | 22.91 | 2.9317 | 160.4 |
| L = 73 cm | 21.8 | 30.1 | 28.7 | 6.91 | 0.11 | 12.43 | 586 | 1.554 | 888 | 162.8 | 886 | 31.8 | 0.027 | 0.771 | 2.422 | 1494 | 951.1 | 3E-04 | 22.92 | 2.9317 | 160.4 |
| PR ~ 2.9 | 21.9 | 30.2 | 28.8 | 6.9 | 0.11 | 12.52 | 586 | 1.557 | 891 | 164.2 | 889 | 32.1 | 0.027 | 0.772 | 2.427 | 1494 | 951.1 | 3E-04 | 23.01 | 2.9374 | 160.4 |
| | | | | | | | | | | 163.7 | 887 | 32 | 0.027 | 0.771 | 2.423 | 1494 | 951.1 | 3E-04 | 22.95 | | |
| | 22.1 | 34.2 | 32 | 9.92 | 0.14 | 15.25 | 586 | 1.557 | 892 | 176.9 | 890 | 34.6 | 0.027 | 0.773 | 2.428 | 1494 | 951.1 | 4E-04 | 23.02 | 2.9374 | 160.4 |
| | 22.3 | 34.6 | 32.4 | 10.1 | 0.14 | 15.39 | 586 | 1.552 | 887 | 175.4 | 884 | 34.3 | 0.027 | 0.771 | 2.421 | 1494 | 951.1 | 4E-04 | 22.88 | 2.928 | 160.4 |
| | 22.3 | 34.9 | 32.7 | 10.4 | 0.14 | 15.42 | 586 | 1.556 | 892 | 170.7 | 889 | 33.4 | 0.027 | 0.772 | 2.427 | 1494 | 951.1 | 4E-04 | 23 | 2.9355 | 160.4 |
| | | | | | | | | | | 174.3 | 888 | 34.1 | 0.027 | 0.772 | 2.425 | 1494 | 951.1 | 4E-04 | 22.97 | | |
| | 22.5 | 38.4 | 35.7 | 13.2 | 0.15 | 17.46 | 586 | 1.554 | 890 | 162.8 | 887 | 31.8 | 0.027 | 0.772 | 2.425 | 1494 | 951.1 | 5E-04 | 22.95 | 2.9317 | 160.4 |
| | 22.6 | 39.2 | 36.3 | 13.7 | 0.16 | 17.65 | 586 | 1.548 | 883 | 169.2 | 880 | 33.1 | 0.027 | 0.769 | 2.416 | 1494 | 951.1 | 5E-04 | 22.78 | 2.9204 | 160.4 |
| | 22.8 | 39.4 | 36.5 | 13.7 | 0.16 | 17.7 | 586 | 1.553 | 890 | 169.8 | 886 | 33.2 | 0.027 | 0.772 | 2.424 | 1494 | 951.1 | 5E-04 | 22.93 | 2.9299 | 160.4 |
| | | | | | | | | | | 167.3 | 885 | 32.7 | 0.027 | 0.771 | 2.421 | 1494 | 951.1 | 5E-04 | 22.89 | | |
| f ~ 585 Hz | 22.7 | 31.4 | 29.8 | 7.08 | 0.12 | 13.21 | 586 | 1.651 | 1005 | 184 | 1002 | 36 | 0.027 | 0.82 | 2.577 | 1494 | 951.1 | 2E-04 | 25.91 | 3.1147 | 161 |
| L = 73 cm | 22.7 | 31.4 | 29.8 | 7.09 | 0.12 | 13.17 | 586 | 1.651 | 1005 | 183.3 | 1002 | 35.8 | 0.027 | 0.82 | 2.577 | 1494 | 951.1 | 2E-04 | 25.91 | 3.1147 | 161 |
| PR ~ 3.1 | 22.7 | 31.5 | 29.9 | 7.19 | 0.12 | 13.2 | 586 | 1.644 | 997 | 181.3 | 993 | 35.4 | 0.027 | 0.817 | 2.566 | 1494 | 951.1 | 2E-04 | 25.7 | 3.1015 | 160.9 |
| | | | | | | | | | | 182.9 | 999 | 35.7 | 0.027 | 0.819 | 2.573 | 1494 | 951.1 | 2E-04 | 25.84 | | |
| | 22.9 | 35.8 | 33.5 | 10.6 | 0.14 | 16.08 | 586 | 1.65 | 1005 | 174.6 | 1001 | 34.1 | 0.027 | 0.82 | 2.576 | 1494 | 951.1 | 3E-04 | 25.89 | 3.1129 | 160.9 |
| | 22.9 | 35.4 | 33.1 | 10.2 | 0.14 | 16.14 | 586 | 1.651 | 1006 | 182.2 | 1002 | 35.6 | 0.027 | 0.82 | 2.578 | 1494 | 951.1 | 3E-04 | 25.92 | 3.1147 | 161 |
| | 22.9 | 35.1 | 32.9 | 9.99 | 0.14 | 15.52 | 586 | 1.65 | 1005 | 178.9 | 1001 | 35 | 0.027 | 0.82 | 2.576 | 1494 | 951.1 | 3E-04 | 25.89 | 3.1129 | 160.9 |
| | | | | | | | | | | 178.6 | 1001 | 34.9 | 0.027 | 0.82 | 2.577 | 1494 | 951.1 | 3E-04 | 25.9 | | |
| | 23 | 39.2 | 36.3 | 13.3 | 0.16 | 18.08 | 586 | 1.645 | 999 | 179.5 | 995 | 35.1 | 0.027 | 0.818 | 2.569 | 1494 | 951.1 | 4E-04 | 25.74 | 3.1034 | 160.9 |
| | 23 | 39.3 | 36.3 | 13.3 | 0.16 | 18.17 | 586 | 1.648 | 1002 | 179.3 | 999 | 35 | 0.027 | 0.819 | 2.573 | 1494 | 951.1 | 4E-04 | 25.83 | 3.1091 | 160.9 |
| | 23.1 | 39.6 | 36.7 | 13.6 | 0.16 | 18.08 | 586 | 1.64 | 993 | 175.5 | 989 | 34.3 | 0.027 | 0.815 | 2.561 | 1494 | 951.1 | 4E-04 | 25.59 | 3.094 | 160.9 |
| | | | | | | | | | | 178.1 | 994 | 34.8 | 0.027 | 0.817 | 2.568 | 1494 | 951.1 | 4E-04 | 25.72 | | |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 585 Hz | 0.1607 | 11.436 | 7.2708 | 7.2708 | 1.7365 | 15.478 | 0.1686 | 0.4545 | 0.002 | 0.4848 |
| L = 73 cm | 0.1592 | 11.406 | 7.0787 | 7.0787 | 1.7078 | 15.273 | 0.1587 | 0.4542 | 0.002 | 0.4845 |
| PR ~ 2.7 | 0.1603 | 11.447 | 7.2779 | 7.2779 | 1.747 | 15.494 | 0.1686 | 0.4552 | 0.002 | 0.4854 |
| | | | | | | 15.415 | | | | 0.4849 |
| | 0.1419 | 9.7465 | 4.9571 | 4.9571 | 1.7122 | 12.128 | 0.1687 | 0.4539 | 0.002 | 0.4842 |
| | 0.1406 | 9.7439 | 4.8746 | 4.8746 | 1.7094 | 12.059 | 0.1687 | 0.4536 | 0.002 | 0.484 |
| | 0.1409 | 9.7351 | 4.8702 | 4.8702 | 1.6997 | 12.047 | 0.1687 | 0.4545 | 0.002 | 0.4848 |
| | | | | | | 12.078 | | | | 0.4843 |
| | 0.1305 | 8.5373 | 3.7227 | 3.7227 | 1.7261 | 10.178 | 0.1686 | 0.4545 | 0.002 | 0.4848 |
| | 0.1297 | 8.5325 | 3.6747 | 3.6747 | 1.7201 | 10.138 | 0.1685 | 0.4549 | 0.002 | 0.4851 |
| | 0.1297 | 8.5325 | 3.6747 | 3.6747 | 1.7201 | 10.138 | 0.1685 | 0.4552 | 0.002 | 0.4854 |
| | | | | | | 10.152 | | | | 0.4851 |
| f ~ 585 Hz | 0.1564 | 11.541 | 7.2493 | 7.2493 | 1.8355 | 15.547 | 0.1696 | 0.4247 | 0.002 | 0.4573 |
| L = 73 cm | 0.1568 | 11.527 | 7.2399 | 7.2399 | 1.8214 | 15.525 | 0.1695 | 0.4247 | 0.002 | 0.4573 |
| PR ~ 2.9 | 0.1563 | 11.543 | 7.2504 | 7.2504 | 1.8373 | 15.55 | 0.1695 | 0.4239 | 0.002 | 0.4565 |
| | | | | | | 15.541 | | | | 0.457 |
| | 0.1409 | 9.319 | 5.0385 | 5.0385 | 1.9793 | 11.898 | 0.1693 | 0.4239 | 0.002 | 0.4565 |
| | 0.14 | 9.3043 | 4.9487 | 4.9487 | 1.9619 | 11.807 | 0.1692 | 0.4253 | 0.002 | 0.4577 |
| | 0.1392 | 9.2602 | 4.808 | 4.808 | 1.9098 | 11.647 | 0.1692 | 0.4242 | 0.002 | 0.4567 |
| | | | | | | 11.784 | | | | 0.457 |
| | 0.1289 | 8.6128 | 3.7792 | 3.7792 | 1.8212 | 10.299 | 0.1691 | 0.4247 | 0.002 | 0.4571 |
| | 0.129 | 8.1661 | 3.644 | 3.644 | 1.8935 | 9.841 | 0.1691 | 0.4264 | 0.002 | 0.4587 |
| | 0.1289 | 8.171 | 3.6461 | 3.6461 | 1.9 | 9.8478 | 0.1689 | 0.425 | 0.002 | 0.4573 |
| | | | | | | 9.9961 | | | | 0.4577 |
| f ~ 585 Hz | 0.1544 | 10.848 | 7.0581 | 7.0581 | 2.0587 | 14.886 | 0.169 | 0.3998 | 0.002 | 0.434 |
| L = 73 cm | 0.1545 | 10.841 | 7.0532 | 7.0532 | 2.051 | 14.874 | 0.169 | 0.3998 | 0.002 | 0.434 |
| PR ~ 3.1 | 0.154 | 10.818 | 6.9586 | 6.9586 | 2.0281 | 14.765 | 0.169 | 0.4015 | 0.002 | 0.4356 |
| | | | | | | 14.842 | | | | 0.4345 |
| | 0.1365 | 9.2967 | 4.7147 | 4.7147 | 1.9529 | 11.607 | 0.1689 | 0.4 | 0.002 | 0.4342 |
| | 0.1372 | 9.3693 | 4.9036 | 4.9036 | 2.0387 | 11.834 | 0.1689 | 0.3998 | 0.002 | 0.434 |
| | 0.1398 | 9.3382 | 5.0075 | 5.0075 | 2.002 | 11.89 | 0.1689 | 0.4 | 0.002 | 0.4342 |
| | | | | | | 11.777 | | | | 0.4341 |
| | 0.1287 | 8.2521 | 3.7733 | 3.7733 | 2.0084 | 10.031 | 0.1688 | 0.4012 | 0.002 | 0.4353 |
| | 0.1284 | 8.2499 | 3.7491 | 3.7491 | 2.0055 | 10.011 | 0.1688 | 0.4005 | 0.002 | 0.4346 |
| | 0.1282 | 8.2188 | 3.6897 | 3.6897 | 1.9639 | 9.9323 | 0.1688 | 0.4024 | 0.002 | 0.4364 |
| | | | | | | 9.9913 | | | | 0.4354 |

| Experiment Information | Ta (C) | Tc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 20.7 | 27.9 | 27.5 | 6.8 | 0.06 | 6.51 | 1199 | 0.504 | 45.5 | 47.22 | 44.9 | 9.23 | 0.056 | 0.122 | 0.383 | 3057 | 1946 | 0.104 | 0.812 | 0.9508 | 150.6 |
| L = 65 cm | 20.7 | 28.1 | 27.7 | 6.99 | 0.06 | 6.66 | 1199 | 0.504 | 45.5 | 46.99 | 44.9 | 9.18 | 0.056 | 0.122 | 0.383 | 3057 | 1946 | 0.107 | 0.812 | 0.9508 | 150.6 |
| PR ~ 0.9 | 20.8 | 28.3 | 27.9 | 7.08 | 0.06 | 6.87 | 1199 | 0.504 | 45.5 | 47.88 | 44.9 | 9.35 | 0.056 | 0.122 | 0.383 | 3057 | 1946 | 0.107 | 0.812 | 0.9508 | 150.6 |
|  |  |  |  |  |  |  |  |  |  | 47.36 | 44.9 | 9.25 | 0.056 | 0.122 | 0.383 | 3057 | 1946 | 0.106 | 0.812 |  |  |
|  | 20.9 | 32.3 | 31.6 | 10.7 | 0.08 | 8.31 | 1200 | 0.506 | 45.8 | 50.98 | 45.2 | 9.96 | 0.056 | 0.122 | 0.384 | 3059 | 1948 | 0.16 | 0.816 | 0.9546 | 150.7 |
|  | 21 | 33.1 | 32.4 | 11.4 | 0.08 | 8.64 | 1200 | 0.507 | 46 | 49.88 | 45.4 | 9.75 | 0.056 | 0.123 | 0.385 | 3059 | 1948 | 0.168 | 0.82 | 0.9565 | 150.7 |
|  | 21 | 33.1 | 32.4 | 11.4 | 0.08 | 8.59 | 1200 | 0.506 | 45.8 | 49.57 | 45.2 | 9.69 | 0.056 | 0.122 | 0.385 | 3059 | 1948 | 0.169 | 0.817 | 0.9546 | 150.7 |
|  |  |  |  |  |  |  |  |  |  | 50.14 | 45.2 | 9.8 | 0.056 | 0.122 | 0.385 | 3059 | 1948 | 0.166 | 0.818 |  |  |
|  | 21.3 | 37.4 | 36.5 | 15.2 | 0.09 | 9.99 | 1200 | 0.507 | 46.1 | 48.69 | 45.5 | 9.51 | 0.056 | 0.123 | 0.385 | 3059 | 1948 | 0.219 | 0.823 | 0.9565 | 150.7 |
|  | 21.5 | 37.5 | 36.6 | 15.1 | 0.09 | 10.09 | 1201 | 0.507 | 46.1 | 49.54 | 45.4 | 9.68 | 0.056 | 0.123 | 0.385 | 3062 | 1949 | 0.216 | 0.821 | 0.9565 | 150.7 |
|  | 21.7 | 37.6 | 36.7 | 15 | 0.09 | 10.15 | 1201 | 0.506 | 45.9 | 50.18 | 45.3 | 9.8 | 0.056 | 0.122 | 0.385 | 3062 | 1949 | 0.214 | 0.819 | 0.9546 | 150.7 |
|  |  |  |  |  |  |  |  |  |  | 49.47 | 45.4 | 9.67 | 0.056 | 0.123 | 0.385 | 3061 | 1949 | 0.216 | 0.821 |  |  |
| f ~ 1200 Hz | 21.6 | 30.3 | 29.8 | 8.2 | 0.07 | 7.01 | 1201 | 0.55 | 54.2 | 49.21 | 53.5 | 9.61 | 0.056 | 0.133 | 0.418 | 3062 | 1949 | 0.084 | 0.967 | 1.0376 | 151.4 |
| L = 65 cm | 21.6 | 29.7 | 29.3 | 7.68 | 0.06 | 6.79 | 1201 | 0.55 | 54.2 | 43.59 | 53.5 | 8.52 | 0.056 | 0.133 | 0.418 | 3062 | 1949 | 0.079 | 0.967 | 1.0376 | 151.4 |
| PR ~ 1.0 | 21.6 | 29.3 | 28.9 | 7.3 | 0.06 | 6.6 | 1201 | 0.55 | 54.2 | 44.63 | 53.5 | 8.72 | 0.056 | 0.133 | 0.418 | 3062 | 1949 | 0.075 | 0.967 | 1.0376 | 151.4 |
|  |  |  |  |  |  |  |  |  |  | 45.81 | 53.5 | 8.95 | 0.056 | 0.133 | 0.418 | 3062 | 1949 | 0.079 | 0.967 |  |  |
|  | 21.8 | 33.8 | 33.1 | 11.3 | 0.08 | 8.8 | 1201 | 0.55 | 54.3 | 51.31 | 53.6 | 10 | 0.056 | 0.133 | 0.418 | 3062 | 1949 | 0.115 | 0.969 | 1.0376 | 151.4 |
|  | 21.8 | 34 | 33.3 | 11.5 | 0.08 | 8.96 | 1201 | 0.549 | 54.1 | 51.39 | 53.4 | 10 | 0.056 | 0.133 | 0.417 | 3062 | 1949 | 0.117 | 0.965 | 1.0357 | 151.4 |
|  | 21.8 | 33.9 | 33.2 | 11.4 | 0.08 | 8.88 | 1201 | 0.549 | 54.1 | 51.35 | 53.4 | 10 | 0.056 | 0.133 | 0.417 | 3062 | 1949 | 0.116 | 0.965 | 1.0357 | 151.4 |
|  |  |  |  |  |  |  |  |  |  | 51.35 | 53.5 | 10 | 0.056 | 0.133 | 0.418 | 3062 | 1949 | 0.116 | 0.966 |  |  |
|  | 21.9 | 37.5 | 36.6 | 14.7 | 0.09 | 10.25 | 1201 | 0.549 | 54.1 | 51.75 | 53.4 | 10.1 | 0.056 | 0.133 | 0.418 | 3062 | 1949 | 0.149 | 0.966 | 1.0357 | 151.4 |
|  | 21.9 | 38.2 | 37.1 | 15.2 | 0.1 | 10.51 | 1202 | 0.549 | 54 | 56.75 | 53.3 | 11.1 | 0.056 | 0.133 | 0.417 | 3064 | 1951 | 0.156 | 0.962 | 1.0357 | 151.4 |
|  | 22 | 38.4 | 37.3 | 15.3 | 0.1 | 10.6 | 1202 | 0.549 | 54.1 | 56.9 | 53.3 | 11.1 | 0.056 | 0.133 | 0.417 | 3064 | 1951 | 0.156 | 0.963 | 1.0357 | 151.4 |
|  |  |  |  |  |  |  |  |  |  | 55.13 | 53.3 | 10.8 | 0.056 | 0.133 | 0.417 | 3064 | 1950 | 0.154 | 0.964 |  |  |
| f ~ 1200 Hz | 22 | 30.4 | 29.9 | 7.88 | 0.07 | 7.04 | 1202 | 0.602 | 65 | 52.86 | 64.1 | 10.3 | 0.056 | 0.146 | 0.458 | 3064 | 1951 | 0.055 | 1.158 | 1.1357 | 152.2 |
| L = 65 cm | 22 | 30.5 | 30 | 7.99 | 0.07 | 7.09 | 1202 | 0.602 | 65 | 51.66 | 64.1 | 10.1 | 0.056 | 0.146 | 0.458 | 3064 | 1951 | 0.056 | 1.158 | 1.1357 | 152.2 |
| PR ~ 1.1 | 22 | 30.3 | 29.8 | 7.8 | 0.07 | 6.99 | 1202 | 0.602 | 65 | 51.73 | 64.1 | 10.1 | 0.056 | 0.146 | 0.458 | 3064 | 1951 | 0.055 | 1.158 | 1.1357 | 152.2 |
|  |  |  |  |  |  |  |  |  |  | 52.09 | 64.1 | 10.2 | 0.056 | 0.146 | 0.458 | 3064 | 1951 | 0.056 | 1.158 |  |  |
|  | 22 | 33.7 | 32.9 | 10.9 | 0.08 | 8.91 | 1202 | 0.601 | 64.8 | 55.34 | 63.9 | 10.8 | 0.056 | 0.145 | 0.457 | 3064 | 1951 | 0.078 | 1.154 | 1.1338 | 152.2 |
|  | 22.1 | 34 | 33.2 | 11.1 | 0.08 | 9.03 | 1202 | 0.601 | 64.8 | 55.1 | 63.9 | 10.8 | 0.056 | 0.145 | 0.457 | 3064 | 1951 | 0.078 | 1.155 | 1.1338 | 152.2 |
|  | 22.1 | 34.3 | 33.5 | 11.4 | 0.08 | 9.03 | 1202 | 0.602 | 65 | 53.84 | 64.1 | 10.5 | 0.056 | 0.146 | 0.458 | 3064 | 1951 | 0.08 | 1.159 | 1.1357 | 152.2 |
|  |  |  |  |  |  |  |  |  |  | 54.76 | 64 | 10.7 | 0.056 | 0.145 | 0.457 | 3064 | 1951 | 0.079 | 1.156 |  |  |
|  | 22.3 | 39.3 | 38.2 | 15.9 | 0.1 | 10.81 | 1202 | 0.602 | 65.1 | 56.97 | 64.3 | 11.1 | 0.056 | 0.146 | 0.458 | 3064 | 1951 | 0.11 | 1.161 | 1.1357 | 152.2 |
|  | 22.4 | 38.8 | 37.7 | 15.3 | 0.1 | 10.55 | 1202 | 0.602 | 65.1 | 58.74 | 64.3 | 11.5 | 0.056 | 0.146 | 0.458 | 3064 | 1951 | 0.105 | 1.162 | 1.1357 | 152.2 |
|  | 22.5 | 39 | 37.9 | 15.4 | 0.1 | 10.63 | 1203 | 0.6 | 64.6 | 58.01 | 63.7 | 11.3 | 0.056 | 0.145 | 0.456 | 3067 | 1953 | 0.107 | 1.151 | 1.1319 | 152.2 |
|  |  |  |  |  |  |  |  |  |  | 57.91 | 64.1 | 11.3 | 0.056 | 0.146 | 0.457 | 3065 | 1951 | 0.107 | 1.158 |  |  |

| Experiment Information | T a (C) | T tc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs / Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 22.3 | 30.3 | 29.8 | 7.45 | 0.07 | 7.7 | 1203 | 0.948 | 161 | 59.49 | 159 | 11.6 | 0.056 | 0.229 | 0.72 | 3067 | 1953 | 0.008 | 2.867 | 1.7885 | 156.1 |
| L = 65 cm | 22.4 | 30.3 | 29.7 | 7.35 | 0.07 | 7.74 | 1203 | 0.949 | 162 | 60.63 | 159 | 11.8 | 0.056 | 0.23 | 0.721 | 3067 | 1953 | 0.008 | 2.876 | 1.7904 | 156.1 |
| PR ~ 1.8 | 22.3 | 30.2 | 29.7 | 7.36 | 0.07 | 7.63 | 1203 | 0.949 | 162 | 59.71 | 159 | 11.7 | 0.056 | 0.229 | 0.721 | 3067 | 1953 | 0.008 | 2.873 | 1.7904 | 156.1 |
| | | | | | | | | | | 59.94 | 159 | 11.7 | 0.056 | 0.229 | 0.721 | 3067 | 1953 | 0.008 | 2.872 | | |
| | 22.4 | 34.2 | 33.3 | 10.9 | 0.09 | 9.75 | 1203 | 0.948 | 161 | 66.17 | 159 | 12.9 | 0.056 | 0.229 | 0.72 | 3067 | 1953 | 0.012 | 2.87 | 1.7885 | 156.1 |
| | 22.4 | 34.1 | 33.2 | 10.8 | 0.09 | 9.68 | 1203 | 0.948 | 161 | 66.26 | 159 | 12.9 | 0.056 | 0.229 | 0.72 | 3067 | 1953 | 0.012 | 2.87 | 1.7885 | 156.1 |
| | 22.5 | 34.5 | 33.6 | 11.1 | 0.09 | 9.85 | 1203 | 0.948 | 161 | 65.69 | 159 | 12.8 | 0.056 | 0.229 | 0.72 | 3067 | 1953 | 0.012 | 2.873 | 1.7885 | 156.1 |
| | | | | | | | | | | 66.04 | 159 | 12.9 | 0.056 | 0.229 | 0.72 | 3067 | 1953 | 0.012 | 2.871 | | |
| | 22.5 | 38.4 | 37.2 | 14.7 | 0.1 | 11.46 | 1203 | 0.947 | 161 | 63.97 | 159 | 12.5 | 0.056 | 0.229 | 0.72 | 3067 | 1953 | 0.017 | 2.866 | 1.7866 | 156.1 |
| | 22.5 | 38.5 | 37.3 | 14.8 | 0.1 | 11.55 | 1203 | 0.947 | 161 | 64.07 | 159 | 12.5 | 0.056 | 0.229 | 0.72 | 3067 | 1953 | 0.017 | 2.866 | 1.7866 | 156.1 |
| | 22.5 | 38.6 | 37.4 | 14.9 | 0.1 | 11.62 | 1203 | 0.947 | 161 | 64.06 | 159 | 12.5 | 0.056 | 0.229 | 0.72 | 3067 | 1953 | 0.017 | 2.866 | 1.7866 | 156.1 |
| | | | | | | | | | | 64.03 | 159 | 12.5 | 0.056 | 0.229 | 0.72 | 3067 | 1953 | 0.017 | 2.866 | | |
| f ~ 1200 Hz | 22.5 | 31.1 | 30.5 | 8.03 | 0.07 | 7.96 | 1203 | 1.004 | 181 | 57.05 | 178 | 11.1 | 0.056 | 0.243 | 0.763 | 3067 | 1953 | 0.007 | 3.222 | 1.8941 | 156.6 |
| L = 65 cm | 22.5 | 31.1 | 30.5 | 8.03 | 0.07 | 7.92 | 1203 | 1.002 | 180 | 56.74 | 178 | 11.1 | 0.056 | 0.242 | 0.762 | 3067 | 1953 | 0.007 | 3.209 | 1.8904 | 156.6 |
| PR ~ 1.9 | 22.5 | 31.1 | 30.4 | 7.94 | 0.08 | 8.08 | 1203 | 1 | 179 | 66.93 | 177 | 13.1 | 0.056 | 0.242 | 0.76 | 3067 | 1953 | 0.007 | 3.196 | 1.8866 | 156.6 |
| | | | | | | | | | | 60.24 | 178 | 11.8 | 0.056 | 0.242 | 0.762 | 3067 | 1953 | 0.007 | 3.209 | | |
| | 22.6 | 34.8 | 33.9 | 11.3 | 0.09 | 10.05 | 1203 | 1.001 | 180 | 65.95 | 178 | 12.9 | 0.056 | 0.242 | 0.761 | 3067 | 1953 | 0.01 | 3.206 | 1.8885 | 156.6 |
| | 22.5 | 34.9 | 34 | 11.5 | 0.09 | 10.12 | 1203 | 1.001 | 180 | 65.29 | 177 | 12.8 | 0.056 | 0.242 | 0.761 | 3067 | 1953 | 0.01 | 3.203 | 1.8885 | 156.6 |
| | 22.6 | 35.1 | 34.2 | 11.6 | 0.09 | 10.18 | 1203 | 1.001 | 180 | 65.14 | 178 | 12.7 | 0.056 | 0.242 | 0.761 | 3067 | 1953 | 0.01 | 3.206 | 1.8885 | 156.6 |
| | | | | | | | | | | 65.46 | 177 | 12.8 | 0.056 | 0.242 | 0.761 | 3067 | 1953 | 0.01 | 3.205 | | |
| | 22.7 | 39.6 | 38.3 | 15.6 | 0.11 | 11.88 | 1203 | 1 | 180 | 69.03 | 177 | 13.5 | 0.056 | 0.242 | 0.76 | 3067 | 1953 | 0.014 | 3.202 | 1.8866 | 156.6 |
| | 22.7 | 39.7 | 38.4 | 15.7 | 0.11 | 11.92 | 1203 | 1 | 180 | 68.84 | 177 | 13.4 | 0.056 | 0.242 | 0.76 | 3067 | 1953 | 0.014 | 3.202 | 1.8866 | 156.6 |
| | 22.7 | 39.4 | 38.1 | 15.4 | 0.11 | 11.96 | 1203 | 1 | 180 | 70.44 | 177 | 13.8 | 0.056 | 0.242 | 0.76 | 3067 | 1953 | 0.014 | 3.202 | 1.8866 | 156.6 |
| | | | | | | | | | | 69.43 | 177 | 13.6 | 0.056 | 0.242 | 0.76 | 3067 | 1953 | 0.014 | 3.202 | | |
| f ~ 1200 Hz | 22.6 | 31.1 | 30.4 | 7.83 | 0.08 | 8.16 | 1203 | 1.054 | 199 | 68.52 | 197 | 13.4 | 0.056 | 0.255 | 0.801 | 3067 | 1953 | 0.006 | 3.554 | 1.9885 | 157.1 |
| L = 65 cm | 22.6 | 31.1 | 30.4 | 7.83 | 0.08 | 8.19 | 1203 | 1.05 | 198 | 68.79 | 195 | 13.4 | 0.056 | 0.254 | 0.798 | 3067 | 1953 | 0.006 | 3.527 | 1.9809 | 157 |
| PR ~ 2.0 | 22.6 | 31.1 | 30.4 | 7.84 | 0.08 | 8.15 | 1203 | 1.054 | 199 | 68.43 | 197 | 13.4 | 0.056 | 0.255 | 0.801 | 3067 | 1953 | 0.006 | 3.554 | 1.9885 | 157.1 |
| | | | | | | | | | | 68.58 | 196 | 13.4 | 0.056 | 0.255 | 0.8 | 3067 | 1953 | 0.006 | 3.545 | | |
| | 22.6 | 34.8 | 33.9 | 11.3 | 0.09 | 10.09 | 1203 | 1.053 | 199 | 66.23 | 196 | 12.9 | 0.056 | 0.255 | 0.8 | 3067 | 1953 | 0.008 | 3.547 | 1.9866 | 157 |
| | 22.6 | 34.9 | 34 | 11.4 | 0.09 | 10.17 | 1203 | 1.05 | 198 | 66.21 | 195 | 12.9 | 0.056 | 0.254 | 0.798 | 3067 | 1953 | 0.008 | 3.527 | 1.9809 | 157 |
| | 22.6 | 35.1 | 34.2 | 11.6 | 0.09 | 10.24 | 1203 | 1.051 | 198 | 65.55 | 196 | 12.8 | 0.056 | 0.254 | 0.799 | 3067 | 1953 | 0.008 | 3.534 | 1.9828 | 157 |
| | | | | | | | | | | 66 | 196 | 12.9 | 0.056 | 0.254 | 0.799 | 3067 | 1953 | 0.008 | 3.536 | | |
| | 22.8 | 39.6 | 38.3 | 15.5 | 0.11 | 12.03 | 1203 | 1.048 | 197 | 70.43 | 195 | 13.8 | 0.056 | 0.254 | 0.797 | 3067 | 1953 | 0.011 | 3.52 | 1.9771 | 157 |
| | 22.8 | 39.7 | 38.3 | 15.5 | 0.11 | 12.11 | 1203 | 1.049 | 198 | 70.48 | 195 | 13.8 | 0.056 | 0.254 | 0.798 | 3067 | 1953 | 0.011 | 3.527 | 1.979 | 157 |
| | 22.8 | 39.4 | 38.1 | 15.3 | 0.11 | 11.97 | 1203 | 1.049 | 198 | 70.96 | 195 | 13.9 | 0.056 | 0.254 | 0.798 | 3067 | 1953 | 0.011 | 3.527 | 1.979 | 157 |
| | | | | | | | | | | 70.62 | 195 | 13.8 | 0.056 | 0.254 | 0.797 | 3067 | 1953 | 0.011 | 3.524 | | |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 0.1948 | 15.8 | 6.3609 | 6.3609 | 0.6194 | 18.193 | 0.1692 | 0.824 | 0.002 | 0.8412 |
| L = 65 cm | 0.197 | 15.826 | 6.607 | 6.607 | 0.6348 | 18.39 | 0.1692 | 0.824 | 0.002 | 0.8412 |
| PR ~ 1.5 | 0.1961 | 15.818 | 6.5233 | 6.5233 | 0.6302 | 18.324 | 0.1692 | 0.824 | 0.002 | 0.8412 |
| | | | | | | 18.302 | | | | 0.8412 |
| | 0.167 | 12.515 | 4.4541 | 4.4541 | 0.7029 | 14.03 | 0.1692 | 0.824 | 0.002 | 0.8412 |
| | 0.1675 | 12.519 | 4.4926 | 4.4926 | 0.706 | 14.058 | 0.1692 | 0.824 | 0.002 | 0.8412 |
| | 0.1661 | 12.507 | 4.3786 | 4.3786 | 0.6961 | 13.974 | 0.1692 | 0.824 | 0.002 | 0.8412 |
| | | | | | | 14.021 | | | | 0.8412 |
| | 0.1511 | 11.296 | 3.3619 | 3.3619 | 0.6842 | 12.276 | 0.1691 | 0.824 | 0.002 | 0.8411 |
| | 0.1506 | 11.294 | 3.3406 | 3.3406 | 0.6829 | 12.263 | 0.1691 | 0.824 | 0.002 | 0.8411 |
| | 0.152 | 11.299 | 3.4054 | 3.4054 | 0.6867 | 12.303 | 0.1691 | 0.824 | 0.002 | 0.8411 |
| | | | | | | 12.28 | | | | 0.8411 |
| f ~ 1200 Hz | 0.1928 | 15.818 | 6.3678 | 6.3678 | 0.6299 | 18.213 | 0.1692 | 0.7765 | 0.002 | 0.7947 |
| L = 65 cm | 0.1929 | 15.831 | 6.45 | 6.45 | 0.638 | 18.283 | 0.1692 | 0.7765 | 0.002 | 0.7947 |
| PR ~ 1.6 | 0.1956 | 15.853 | 6.7013 | 6.7013 | 0.6517 | 18.483 | 0.1692 | 0.7765 | 0.002 | 0.7947 |
| | | | | | | 18.326 | | | | 0.7947 |
| | 0.1666 | 12.529 | 4.496 | 4.496 | 0.7133 | 14.069 | 0.1691 | 0.7756 | 0.002 | 0.7938 |
| | 0.1663 | 12.532 | 4.4971 | 4.4971 | 0.7157 | 14.072 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| | 0.165 | 12.526 | 4.4212 | 4.4212 | 0.7109 | 14.019 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| | | | | | | 14.053 | | | | 0.7944 |
| | 0.1495 | 11.3 | 3.3216 | 3.3216 | 0.6876 | 12.258 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| | 0.149 | 11.298 | 3.3007 | 3.3007 | 0.6863 | 12.245 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| | 0.1502 | 11.304 | 3.3644 | 3.3644 | 0.6915 | 12.285 | 0.1691 | 0.7756 | 0.002 | 0.7938 |
| | | | | | | 12.263 | | | | 0.7944 |
| f ~ 1200 Hz | 0.1933 | 15.843 | 6.5336 | 6.5336 | 0.6455 | 18.353 | 0.1691 | 0.7309 | 0.002 | 0.7502 |
| L = 65 cm | 0.1933 | 15.843 | 6.5336 | 6.5336 | 0.6455 | 18.353 | 0.1692 | 0.7293 | 0.002 | 0.7486 |
| PR ~ 1.7 | 0.1943 | 15.85 | 6.617 | 6.617 | 0.6494 | 18.419 | 0.1692 | 0.7293 | 0.002 | 0.7486 |
| | | | | | | 18.375 | | | | 0.7492 |
| | 0.1663 | 12.541 | 4.5383 | 4.5383 | 0.723 | 14.108 | 0.1691 | 0.7333 | 0.002 | 0.7526 |
| | 0.1652 | 12.533 | 4.4603 | 4.4603 | 0.7165 | 14.05 | 0.1691 | 0.7333 | 0.002 | 0.7526 |
| | 0.1657 | 12.538 | 4.4993 | 4.4993 | 0.7205 | 14.08 | 0.1691 | 0.7341 | 0.002 | 0.7534 |
| | | | | | | 14.079 | | | | 0.7528 |
| | 0.1489 | 11.311 | 3.3456 | 3.3456 | 0.6975 | 12.282 | 0.1691 | 0.7358 | 0.002 | 0.755 |
| | 0.1498 | 11.315 | 3.3889 | 3.3889 | 0.7009 | 12.309 | 0.1691 | 0.7358 | 0.002 | 0.755 |
| | 0.1489 | 11.312 | 3.3458 | 3.3458 | 0.6981 | 12.283 | 0.1691 | 0.735 | 0.002 | 0.7542 |
| | | | | | | 12.291 | | | | 0.7547 |

| Experiment Information | T a (C) | T tc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs/Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 22.4 | 30.8 | 30.3 | 7.86 | 0.07 | 7.56 | 1203 | 0.801 | 115 | 55.36 | 113 | 10.8 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.017 | 2.049 | 1.5111 | 154.7 |
| L = 65 cm | 22.4 | 30.5 | 30 | 7.57 | 0.07 | 7.46 | 1203 | 0.801 | 115 | 56.74 | 113 | 11.1 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.017 | 2.049 | 1.5111 | 154.7 |
| PR ~ 1.5 | 22.4 | 30.6 | 30.1 | 7.66 | 0.07 | 7.5 | 1203 | 0.801 | 115 | 56.32 | 113 | 11 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.017 | 2.049 | 1.5111 | 154.7 |
|  |  |  |  |  |  |  |  |  |  | 56.14 | 113 | 11 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.017 | 2.049 |  |  |
|  | 22.4 | 34.5 | 33.6 | 11.2 | 0.09 | 9.53 | 1203 | 0.801 | 115 | 62.83 | 113 | 12.3 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.025 | 2.049 | 1.5111 | 154.7 |
|  | 22.4 | 34.4 | 33.5 | 11.1 | 0.09 | 9.49 | 1203 | 0.801 | 115 | 63.11 | 113 | 12.3 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.025 | 2.049 | 1.5111 | 154.7 |
|  | 22.4 | 34.7 | 33.8 | 11.4 | 0.09 | 9.6 | 1203 | 0.801 | 115 | 62.22 | 113 | 12.2 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.025 | 2.049 | 1.5111 | 154.7 |
|  |  |  |  |  |  |  |  |  |  | 62.72 | 113 | 12.3 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.025 | 2.049 |  |  |
|  | 22.5 | 38.5 | 37.4 | 14.9 | 0.1 | 11.06 | 1203 | 0.801 | 115 | 61.15 | 114 | 11.9 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.033 | 2.051 | 1.5111 | 154.7 |
|  | 22.5 | 38.6 | 37.5 | 15 | 0.1 | 11.11 | 1203 | 0.801 | 115 | 61.04 | 114 | 11.9 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.033 | 2.051 | 1.5111 | 154.7 |
|  | 22.5 | 38.3 | 37.2 | 14.7 | 0.1 | 10.96 | 1203 | 0.801 | 115 | 61.38 | 114 | 12 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.032 | 2.051 | 1.5111 | 154.7 |
|  |  |  |  |  |  |  |  |  |  | 61.19 | 114 | 12 | 0.056 | 0.194 | 0.609 | 3067 | 1953 | 0.033 | 2.051 |  |  |
| f ~ 1200 Hz | 22.4 | 30.8 | 30.3 | 7.85 | 0.07 | 7.68 | 1203 | 0.85 | 130 | 56.3 | 128 | 11 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.014 | 2.307 | 1.6036 | 155.2 |
| L = 65 cm | 22.4 | 30.7 | 30.2 | 7.75 | 0.07 | 7.68 | 1203 | 0.85 | 130 | 57.03 | 128 | 11.1 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.013 | 2.307 | 1.6036 | 155.2 |
| PR ~ 1.6 | 22.4 | 30.4 | 29.9 | 7.46 | 0.07 | 7.55 | 1203 | 0.85 | 130 | 58.25 | 128 | 11.4 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.013 | 2.307 | 1.6036 | 155.2 |
|  |  |  |  |  |  |  |  |  |  | 57.19 | 128 | 11.2 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.013 | 2.307 |  |  |
|  | 22.5 | 34.5 | 33.6 | 11.1 | 0.09 | 9.58 | 1203 | 0.851 | 130 | 63.75 | 128 | 12.5 | 0.056 | 0.206 | 0.647 | 3067 | 1953 | 0.019 | 2.315 | 1.6055 | 155.2 |
|  | 22.5 | 34.5 | 33.6 | 11.1 | 0.09 | 9.61 | 1203 | 0.85 | 130 | 63.97 | 128 | 12.5 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.019 | 2.309 | 1.6036 | 155.2 |
|  | 22.5 | 34.7 | 33.8 | 11.3 | 0.09 | 9.71 | 1203 | 0.85 | 130 | 63.54 | 128 | 12.4 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.02 | 2.309 | 1.6036 | 155.2 |
|  |  |  |  |  |  |  |  |  |  | 63.75 | 128 | 12.5 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.019 | 2.311 |  |  |
|  | 22.6 | 38.8 | 37.7 | 15.1 | 0.1 | 11.25 | 1203 | 0.85 | 130 | 61.45 | 128 | 12 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.026 | 2.311 | 1.6036 | 155.2 |
|  | 22.6 | 38.9 | 37.7 | 15.1 | 0.1 | 11.3 | 1203 | 0.85 | 130 | 61.34 | 128 | 12 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.026 | 2.311 | 1.6036 | 155.2 |
|  | 22.6 | 38.6 | 37.5 | 14.9 | 0.1 | 11.17 | 1203 | 0.851 | 130 | 61.81 | 128 | 12.1 | 0.056 | 0.206 | 0.647 | 3067 | 1953 | 0.025 | 2.317 | 1.6055 | 155.2 |
|  |  |  |  |  |  |  |  |  |  | 61.53 | 128 | 12 | 0.056 | 0.206 | 0.646 | 3067 | 1953 | 0.026 | 2.313 |  |  |
| f ~ 1200 Hz | 22.5 | 30.7 | 30.2 | 7.65 | 0.07 | 7.67 | 1203 | 0.903 | 146 | 57.69 | 144 | 11.3 | 0.056 | 0.218 | 0.686 | 3067 | 1953 | 0.01 | 2.606 | 1.7036 | 155.7 |
| L = 65 cm | 22.4 | 30.6 | 30.1 | 7.65 | 0.07 | 7.67 | 1203 | 0.905 | 147 | 57.69 | 145 | 11.3 | 0.056 | 0.219 | 0.688 | 3067 | 1953 | 0.01 | 2.615 | 1.7074 | 155.7 |
| PR ~ 1.7 | 22.4 | 30.5 | 30 | 7.56 | 0.07 | 7.62 | 1203 | 0.905 | 147 | 58.05 | 145 | 11.3 | 0.056 | 0.219 | 0.688 | 3067 | 1953 | 0.01 | 2.615 | 1.7074 | 155.7 |
|  |  |  |  |  |  |  |  |  |  | 57.81 | 145 | 11.3 | 0.056 | 0.219 | 0.687 | 3067 | 1953 | 0.01 | 2.612 |  |  |
|  | 22.5 | 34.4 | 33.5 | 11 | 0.09 | 9.62 | 1203 | 0.9 | 145 | 64.62 | 143 | 12.6 | 0.056 | 0.218 | 0.684 | 3067 | 1953 | 0.015 | 2.589 | 1.6979 | 155.7 |
|  | 22.5 | 34.6 | 33.7 | 11.2 | 0.09 | 9.7 | 1203 | 0.9 | 145 | 64.04 | 143 | 12.5 | 0.056 | 0.218 | 0.684 | 3067 | 1953 | 0.015 | 2.589 | 1.6979 | 155.7 |
|  | 22.5 | 34.5 | 33.6 | 11.1 | 0.09 | 9.67 | 1203 | 0.899 | 145 | 64.4 | 143 | 12.6 | 0.056 | 0.217 | 0.683 | 3067 | 1953 | 0.015 | 2.583 | 1.696 | 155.7 |
|  |  |  |  |  |  |  |  |  |  | 64.35 | 143 | 12.6 | 0.056 | 0.218 | 0.684 | 3067 | 1953 | 0.015 | 2.587 |  |  |
|  | 22.6 | 38.7 | 37.5 | 14.9 | 0.1 | 11.33 | 1203 | 0.897 | 144 | 62.34 | 143 | 12.2 | 0.056 | 0.217 | 0.682 | 3067 | 1953 | 0.021 | 2.574 | 1.6923 | 155.7 |
|  | 22.6 | 38.5 | 37.4 | 14.8 | 0.1 | 11.24 | 1203 | 0.897 | 144 | 62.64 | 143 | 12.2 | 0.056 | 0.217 | 0.682 | 3067 | 1953 | 0.02 | 2.574 | 1.6923 | 155.7 |
|  | 22.6 | 38.7 | 37.5 | 14.9 | 0.1 | 11.34 | 1203 | 0.898 | 145 | 62.4 | 143 | 12.2 | 0.056 | 0.217 | 0.683 | 3067 | 1953 | 0.021 | 2.58 | 1.6941 | 155.7 |
|  |  |  |  |  |  |  |  |  |  | 62.46 | 143 | 12.2 | 0.056 | 0.217 | 0.682 | 3067 | 1953 | 0.021 | 2.576 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 0.1971 | 15.491 | 6.1921 | 6.1921 | 0.587 | 17.805 | 0.1692 | 1.0092 | 0.002 | 1.0233 |
| L = 65 cm | 0.198 | 15.451 | 6.2669 | 6.2669 | 0.59 | 17.823 | 0.1692 | 1.0092 | 0.002 | 1.0233 |
| PR ~ 1.2 | 0.1933 | 14.834 | 6.6083 | 6.6083 | 0.6367 | 17.545 | 0.1692 | 1.0092 | 0.002 | 1.0233 |
| | | | | | | 17.724 | | | | 1.0233 |
| | 0.165 | 13.524 | 4.3747 | 4.3747 | 0.6085 | 14.885 | 0.1692 | 1.0092 | 0.002 | 1.0233 |
| | 0.1673 | 12.359 | 4.2601 | 4.2601 | 0.6639 | 13.766 | 0.1691 | 1.0092 | 0.002 | 1.0232 |
| | 0.1674 | 12.392 | 4.2242 | 4.2242 | 0.6582 | 13.773 | 0.1691 | 1.0076 | 0.002 | 1.0217 |
| | | | | | | 14.142 | | | | 1.0227 |
| | 0.1524 | 11.356 | 3.1868 | 3.1868 | 0.6386 | 12.236 | 0.169 | 1.0061 | 0.002 | 1.0202 |
| | 0.1509 | 11.188 | 3.23 | 3.23 | 0.6532 | 12.103 | 0.1689 | 1.0061 | 0.002 | 1.0202 |
| | 0.1502 | 11.103 | 3.2517 | 3.2517 | 0.6593 | 12.037 | 0.1689 | 1.0061 | 0.002 | 1.0202 |
| | | | | | | 12.125 | | | | 1.0202 |
| f ~ 1200 Hz | 0.1986 | 15.797 | 6.5148 | 6.5148 | 0.6176 | 18.299 | 0.1696 | 0.9375 | 0.002 | 0.9527 |
| L = 65 cm | 0.1995 | 15.79 | 6.5118 | 6.5118 | 0.6131 | 18.291 | 0.1696 | 0.9375 | 0.002 | 0.9527 |
| PR ~ 1.3 | 0.1962 | 15.789 | 6.3563 | 6.3563 | 0.6124 | 18.18 | 0.1696 | 0.9375 | 0.002 | 0.9527 |
| | | | | | | 18.257 | | | | 0.9527 |
| | 0.1675 | 12.484 | 4.3354 | 4.3354 | 0.6785 | 13.926 | 0.1695 | 0.9362 | 0.002 | 0.9514 |
| | 0.1679 | 12.473 | 4.2968 | 4.2968 | 0.6696 | 13.891 | 0.1695 | 0.9362 | 0.002 | 0.9514 |
| | 0.168 | 12.48 | 4.334 | 4.334 | 0.6754 | 13.921 | 0.1695 | 0.9388 | 0.002 | 0.954 |
| | | | | | | 13.913 | | | | 0.9523 |
| | 0.1521 | 11.262 | 3.2701 | 3.2701 | 0.6553 | 12.193 | 0.1693 | 0.9388 | 0.002 | 0.954 |
| | 0.1512 | 11.26 | 3.23 | 3.23 | 0.6532 | 12.17 | 0.1692 | 0.9375 | 0.002 | 0.9527 |
| | 0.1508 | 11.252 | 3.1895 | 3.1895 | 0.6467 | 12.141 | 0.1692 | 0.9348 | 0.002 | 0.95 |
| | | | | | | 12.168 | | | | 0.9522 |
| f ~ 1200 Hz | 0.1963 | 15.971 | 6.4381 | 6.4381 | 0.6203 | 18.395 | 0.1692 | 0.8812 | 0.002 | 0.8973 |
| L = 65 cm | 0.1973 | 15.872 | 6.5191 | 6.5191 | 0.6239 | 18.367 | 0.1692 | 0.88 | 0.002 | 0.8961 |
| PR ~ 1.4 | 0.1955 | 15.76 | 6.2782 | 6.2782 | 0.6073 | 18.1 | 0.1693 | 0.88 | 0.002 | 0.8961 |
| | | | | | | 18.287 | | | | 0.8965 |
| | 0.1667 | 12.492 | 4.3381 | 4.3381 | 0.6846 | 13.935 | 0.1693 | 0.8788 | 0.002 | 0.895 |
| | 0.166 | 12.36 | 4.3029 | 4.3029 | 0.6833 | 13.795 | 0.1693 | 0.8788 | 0.002 | 0.895 |
| | 0.1671 | 12.637 | 4.2991 | 4.2991 | 0.6749 | 14.041 | 0.1692 | 0.8788 | 0.002 | 0.895 |
| | | | | | | 13.924 | | | | 0.895 |
| | 0.1508 | 11.28 | 3.2523 | 3.2523 | 0.6613 | 12.2 | 0.1692 | 0.88 | 0.002 | 0.8961 |
| | 0.1525 | 11.516 | 3.3807 | 3.3807 | 0.6774 | 12.488 | 0.1691 | 0.88 | 0.002 | 0.8961 |
| | 0.1508 | 11.178 | 3.2954 | 3.2954 | 0.6706 | 12.13 | 0.1691 | 0.88 | 0.002 | 0.8961 |
| | | | | | | 12.273 | | | | 0.8961 |

| Experiment Information | Ta (C) | T to (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs/Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 22.4 | 31 | 30.5 | 8.07 | 0.07 | 7.24 | 1203 | 0.654 | 76.7 | 52.47 | 75.6 | 10.3 | 0.056 | 0.158 | 0.497 | 3067 | 1953 | 0.04 | 1.366 | 1.2338 | 152.9 |
| L = 65 cm | 22.4 | 30.9 | 30.4 | 7.98 | 0.07 | 7.17 | 1203 | 0.654 | 76.7 | 52.74 | 75.6 | 10.3 | 0.056 | 0.158 | 0.497 | 3067 | 1953 | 0.04 | 1.366 | 1.2338 | 152.9 |
| PR ~ 1.2 | 22.4 | 30.5 | 30 | 7.57 | 0.07 | 7.01 | 1203 | 0.654 | 76.7 | 56.9 | 75.6 | 11.1 | 0.056 | 0.158 | 0.497 | 3067 | 1953 | 0.038 | 1.366 | 1.2338 | 152.9 |
|  |  |  |  |  |  |  |  |  |  | 54.04 | 75.6 | 10.6 | 0.056 | 0.158 | 0.497 | 3067 | 1953 | 0.039 | 1.366 |  |  |
|  | 22.4 | 34.6 | 33.8 | 11.4 | 0.08 | 9.21 | 1203 | 0.654 | 76.7 | 54.39 | 75.6 | 10.6 | 0.056 | 0.158 | 0.497 | 3067 | 1953 | 0.057 | 1.366 | 1.2338 | 152.9 |
|  | 22.5 | 35.1 | 34.2 | 11.7 | 0.09 | 9.33 | 1203 | 0.654 | 76.8 | 59.34 | 75.7 | 11.6 | 0.056 | 0.158 | 0.497 | 3067 | 1953 | 0.058 | 1.367 | 1.2338 | 152.9 |
|  | 22.5 | 35.2 | 34.3 | 11.8 | 0.09 | 9.36 | 1203 | 0.655 | 77 | 58.83 | 75.9 | 11.5 | 0.056 | 0.158 | 0.498 | 3067 | 1953 | 0.058 | 1.371 | 1.2357 | 152.9 |
|  |  |  |  |  |  |  |  |  |  | 57.52 | 75.8 | 11.2 | 0.056 | 0.158 | 0.497 | 3067 | 1953 | 0.058 | 1.368 |  |  |
|  | 22.7 | 39.5 | 38.4 | 15.7 | 0.1 | 11 | 1203 | 0.656 | 77.3 | 57.07 | 76.3 | 11.2 | 0.056 | 0.159 | 0.499 | 3067 | 1953 | 0.075 | 1.378 | 1.2376 | 152.9 |
|  | 22.8 | 39.4 | 38.3 | 15.5 | 0.1 | 10.92 | 1203 | 0.656 | 77.3 | 58.38 | 76.4 | 11.4 | 0.056 | 0.159 | 0.499 | 3067 | 1953 | 0.074 | 1.379 | 1.2376 | 152.9 |
|  | 22.8 | 39.3 | 38.2 | 15.4 | 0.1 | 10.86 | 1203 | 0.656 | 77.3 | 58.93 | 76.4 | 11.5 | 0.056 | 0.159 | 0.499 | 3067 | 1953 | 0.074 | 1.379 | 1.2376 | 152.9 |
|  |  |  |  |  |  |  |  |  |  | 58.13 | 76.4 | 11.4 | 0.056 | 0.159 | 0.499 | 3067 | 1953 | 0.074 | 1.379 |  |  |
| f ~ 1200 Hz | 21.6 | 29.8 | 29.3 | 7.67 | 0.07 | 7.36 | 1202 | 0.704 | 88.8 | 55.2 | 87.3 | 10.8 | 0.056 | 0.17 | 0.535 | 3064 | 1951 | 0.03 | 1.577 | 1.3282 | 153.6 |
| L = 65 cm | 21.6 | 29.8 | 29.3 | 7.68 | 0.07 | 7.31 | 1202 | 0.704 | 88.8 | 54.8 | 87.3 | 10.7 | 0.056 | 0.17 | 0.535 | 3064 | 1951 | 0.03 | 1.577 | 1.3282 | 153.6 |
| PR ~ 1.3 | 21.7 | 30.1 | 29.6 | 7.87 | 0.07 | 7.48 | 1202 | 0.704 | 88.8 | 54.73 | 87.4 | 10.7 | 0.056 | 0.17 | 0.535 | 3064 | 1951 | 0.03 | 1.579 | 1.3282 | 153.6 |
|  |  |  |  |  |  |  |  |  |  | 54.91 | 87.4 | 10.7 | 0.056 | 0.17 | 0.535 | 3064 | 1951 | 0.03 | 1.578 |  |  |
|  | 21.9 | 34.3 | 33.4 | 11.5 | 0.09 | 9.45 | 1203 | 0.705 | 89 | 60.64 | 87.5 | 11.8 | 0.056 | 0.17 | 0.535 | 3067 | 1953 | 0.044 | 1.58 | 1.33 | 153.6 |
|  | 21.9 | 34.4 | 33.5 | 11.6 | 0.09 | 9.41 | 1203 | 0.705 | 89 | 59.85 | 87.5 | 11.7 | 0.056 | 0.17 | 0.535 | 3067 | 1953 | 0.044 | 1.58 | 1.33 | 153.6 |
|  | 21.9 | 34.3 | 33.4 | 11.5 | 0.09 | 9.41 | 1203 | 0.703 | 88.5 | 60.36 | 87 | 11.8 | 0.056 | 0.17 | 0.534 | 3067 | 1953 | 0.044 | 1.571 | 1.3263 | 153.5 |
|  |  |  |  |  |  |  |  |  |  | 60.28 | 87.3 | 11.8 | 0.056 | 0.17 | 0.535 | 3067 | 1953 | 0.044 | 1.577 |  |  |
|  | 22.2 | 38.6 | 37.5 | 15.3 | 0.1 | 10.89 | 1203 | 0.703 | 88.6 | 58.57 | 87.2 | 11.4 | 0.056 | 0.17 | 0.534 | 3067 | 1953 | 0.058 | 1.575 | 1.3263 | 153.5 |
|  | 22.3 | 38.9 | 37.8 | 15.5 | 0.1 | 10.99 | 1203 | 0.704 | 88.9 | 58.38 | 87.6 | 11.4 | 0.056 | 0.17 | 0.535 | 3067 | 1953 | 0.058 | 1.581 | 1.3282 | 153.6 |
|  | 22.3 | 39.1 | 38 | 15.7 | 0.1 | 11.02 | 1203 | 0.706 | 89.4 | 57.8 | 88.1 | 11.3 | 0.056 | 0.171 | 0.536 | 3067 | 1953 | 0.058 | 1.59 | 1.3319 | 153.6 |
|  |  |  |  |  |  |  |  |  |  | 58.25 | 87.6 | 11.4 | 0.056 | 0.17 | 0.535 | 3067 | 1953 | 0.058 | 1.582 |  |  |
| f ~ 1200 Hz | 22.3 | 30.6 | 30.1 | 7.77 | 0.07 | 7.48 | 1203 | 0.749 | 101 | 55.44 | 99.1 | 10.8 | 0.056 | 0.181 | 0.569 | 3067 | 1953 | 0.023 | 1.79 | 1.413 | 154.1 |
| L = 65 cm | 22.3 | 30.5 | 30 | 7.67 | 0.07 | 7.43 | 1203 | 0.75 | 101 | 55.76 | 99.4 | 10.9 | 0.056 | 0.181 | 0.57 | 3067 | 1953 | 0.022 | 1.795 | 1.4149 | 154.1 |
| PR ~ 1.4 | 22.2 | 30.7 | 30.2 | 7.96 | 0.07 | 7.51 | 1203 | 0.75 | 101 | 54.28 | 99.3 | 10.6 | 0.056 | 0.181 | 0.57 | 3067 | 1953 | 0.023 | 1.793 | 1.4149 | 154.1 |
|  |  |  |  |  |  |  |  |  |  | 55.16 | 99.3 | 10.8 | 0.056 | 0.181 | 0.57 | 3067 | 1953 | 0.023 | 1.792 |  |  |
|  | 22.2 | 34.6 | 33.7 | 11.5 | 0.09 | 9.53 | 1203 | 0.751 | 101 | 61.19 | 99.6 | 12 | 0.056 | 0.182 | 0.57 | 3067 | 1953 | 0.033 | 1.798 | 1.4168 | 154.1 |
|  | 22.2 | 34.7 | 33.8 | 11.6 | 0.09 | 9.59 | 1203 | 0.751 | 101 | 61.08 | 99.6 | 11.9 | 0.056 | 0.182 | 0.57 | 3067 | 1953 | 0.034 | 1.798 | 1.4168 | 154.1 |
|  | 22.3 | 34.8 | 33.9 | 11.6 | 0.09 | 9.48 | 1203 | 0.751 | 101 | 60.32 | 99.7 | 11.8 | 0.056 | 0.182 | 0.571 | 3067 | 1953 | 0.033 | 1.799 | 1.4168 | 154.1 |
|  |  |  |  |  |  |  |  |  |  | 60.86 | 99.6 | 11.9 | 0.056 | 0.182 | 0.57 | 3067 | 1953 | 0.033 | 1.798 |  |  |
|  | 22.4 | 38.9 | 37.8 | 15.4 | 0.1 | 11.05 | 1203 | 0.75 | 101 | 59.1 | 99.5 | 11.5 | 0.056 | 0.181 | 0.57 | 3067 | 1953 | 0.044 | 1.796 | 1.4149 | 154.1 |
|  | 22.5 | 38.4 | 37.3 | 14.8 | 0.1 | 10.89 | 1203 | 0.75 | 101 | 60.55 | 99.6 | 11.8 | 0.056 | 0.181 | 0.57 | 3067 | 1953 | 0.042 | 1.798 | 1.4149 | 154.1 |
|  | 22.5 | 38.8 | 37.7 | 15.2 | 0.1 | 11.06 | 1203 | 0.75 | 101 | 59.94 | 99.6 | 11.7 | 0.056 | 0.181 | 0.57 | 3067 | 1953 | 0.043 | 1.798 | 1.4149 | 154.1 |
|  |  |  |  |  |  |  |  |  |  | 59.86 | 99.5 | 11.7 | 0.056 | 0.181 | 0.57 | 3067 | 1953 | 0.043 | 1.797 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 0.2155 | 18.172 | 7.351 | 7.351 | 0.5283 | 20.943 | 0.1702 | 1.3095 | 0.002 | 1.3205 |
| L = 65 cm | 0.2118 | 18.167 | 7.1504 | 7.1504 | 0.5257 | 20.799 | 0.1702 | 1.3095 | 0.002 | 1.3205 |
| PR ~ 0.9 | 0.2072 | 18.185 | 7.0623 | 7.0623 | 0.5356 | 20.756 | 0.1701 | 1.3095 | 0.002 | 1.3205 |
| | | | | | | 20.833 | | | | 1.3205 |
| | 0.1811 | 13.822 | 4.6632 | 4.6632 | 0.5704 | 15.326 | 0.17 | 1.3043 | 0.002 | 1.3154 |
| | 0.176 | 13.804 | 4.3877 | 4.3877 | 0.558 | 15.146 | 0.17 | 1.3018 | 0.002 | 1.3128 |
| | 0.1766 | 13.799 | 4.3862 | 4.3862 | 0.5546 | 15.14 | 0.17 | 1.3043 | 0.002 | 1.3154 |
| | | | | | | 15.204 | | | | 1.3145 |
| | 0.1592 | 12.312 | 3.2931 | 3.2931 | 0.5448 | 13.176 | 0.1698 | 1.3018 | 0.002 | 1.3128 |
| | 0.1583 | 12.324 | 3.3169 | 3.3169 | 0.5542 | 13.199 | 0.1697 | 1.3018 | 0.002 | 1.3128 |
| | 0.1578 | 12.333 | 3.3403 | 3.3403 | 0.5614 | 13.22 | 0.1696 | 1.3043 | 0.002 | 1.3153 |
| | | | | | | 13.198 | | | | 1.3136 |
| f ~ 1200 Hz | 0.2044 | 15.688 | 6.0977 | 6.0977 | 0.5506 | 17.911 | 0.1696 | 1.2 | 0.002 | 1.2119 |
| L = 65 cm | 0.2079 | 18.094 | 6.5064 | 6.5064 | 0.4877 | 20.307 | 0.1696 | 1.2 | 0.002 | 1.2119 |
| PR ~ 1.0 | 0.2127 | 18.116 | 6.8528 | 6.8528 | 0.4993 | 20.553 | 0.1696 | 1.2 | 0.002 | 1.2119 |
| | | | | | | 19.59 | | | | 1.2119 |
| | 0.174 | 13.827 | 4.4317 | 4.4317 | 0.5741 | 15.193 | 0.1695 | 1.2 | 0.002 | 1.2119 |
| | 0.1719 | 13.828 | 4.3595 | 4.3595 | 0.575 | 15.152 | 0.1695 | 1.2022 | 0.002 | 1.2141 |
| | 0.173 | 13.828 | 4.3953 | 4.3953 | 0.5745 | 15.172 | 0.1695 | 1.2022 | 0.002 | 1.2141 |
| | | | | | | 15.172 | | | | 1.2134 |
| | 0.157 | 12.356 | 3.4107 | 3.4107 | 0.5789 | 13.278 | 0.1695 | 1.2022 | 0.002 | 1.2141 |
| | 0.1554 | 11.239 | 3.2833 | 3.2833 | 0.6349 | 12.178 | 0.1695 | 1.2022 | 0.002 | 1.2141 |
| | 0.1545 | 11.241 | 3.2638 | 3.2638 | 0.6366 | 12.169 | 0.1694 | 1.2022 | 0.002 | 1.2141 |
| | | | | | | 12.541 | | | | 1.2141 |
| f ~ 1200 Hz | 0.199 | 15.755 | 6.3425 | 6.3425 | 0.5914 | 18.14 | 0.1694 | 1.0963 | 0.002 | 1.1094 |
| L = 65 cm | 0.201 | 15.733 | 6.2591 | 6.2591 | 0.578 | 18.062 | 0.1694 | 1.0963 | 0.002 | 1.1094 |
| PR ~ 1.1 | 0.2049 | 15.734 | 6.4104 | 6.4104 | 0.5788 | 18.169 | 0.1694 | 1.0963 | 0.002 | 1.1094 |
| | | | | | | 18.124 | | | | 1.1094 |
| | 0.1677 | 13.892 | 4.5667 | 4.5667 | 0.6191 | 15.333 | 0.1694 | 1.0982 | 0.002 | 1.1112 |
| | 0.1662 | 13.888 | 4.4887 | 4.4887 | 0.6165 | 15.283 | 0.1693 | 1.0982 | 0.002 | 1.1112 |
| | 0.1654 | 13.868 | 4.3719 | 4.3719 | 0.6024 | 15.196 | 0.1693 | 1.0963 | 0.002 | 1.1093 |
| | | | | | | 15.271 | | | | 1.1106 |
| | 0.1499 | 11.241 | 3.1489 | 3.1489 | 0.6373 | 12.109 | 0.1692 | 1.0963 | 0.002 | 1.1093 |
| | 0.1501 | 11.265 | 3.2708 | 3.2708 | 0.6572 | 12.196 | 0.1692 | 1.0963 | 0.002 | 1.1093 |
| | 0.1512 | 11.255 | 3.2482 | 3.2482 | 0.6491 | 12.175 | 0.1691 | 1.1 | 0.002 | 1.1129 |
| | | | | | | 12.16 | | | | 1.1105 |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 0.1931 | 15.876 | 6.7109 | 6.7109 | 0.6656 | 18.51 | 0.1692 | 0.6962 | 0.002 | 0.7165 |
| L = 65 cm | 0.1927 | 15.897 | 6.8048 | 6.8048 | 0.6784 | 18.596 | 0.1692 | 0.6955 | 0.002 | 0.7158 |
| PR ~ 1.8 | 0.1945 | 15.88 | 6.7976 | 6.7976 | 0.668 | 18.576 | 0.1692 | 0.6955 | 0.002 | 0.7158 |
|  |  |  |  |  |  | 18.561 |  |  |  | 0.716 |
|  | 0.1651 | 12.563 | 4.5848 | 4.5848 | 0.7403 | 14.158 | 0.1692 | 0.6962 | 0.002 | 0.7165 |
|  | 0.1659 | 12.565 | 4.6245 | 4.6245 | 0.7413 | 14.185 | 0.1692 | 0.6962 | 0.002 | 0.7165 |
|  | 0.1639 | 12.557 | 4.506 | 4.506 | 0.735 | 14.101 | 0.1691 | 0.6962 | 0.002 | 0.7165 |
|  |  |  |  |  |  | 14.148 |  |  |  | 0.7165 |
|  | 0.1481 | 11.333 | 3.394 | 3.394 | 0.7157 | 12.329 | 0.1691 | 0.6969 | 0.002 | 0.7172 |
|  | 0.1474 | 11.334 | 3.3732 | 3.3732 | 0.7169 | 12.319 | 0.1691 | 0.6969 | 0.002 | 0.7172 |
|  | 0.1469 | 11.334 | 3.3522 | 3.3522 | 0.7167 | 12.307 | 0.1691 | 0.6969 | 0.002 | 0.7172 |
|  |  |  |  |  |  | 12.318 |  |  |  | 0.7172 |
| f ~ 1200 Hz | 0.188 | 15.831 | 6.2251 | 6.2251 | 0.6382 | 18.127 | 0.1691 | 0.6574 | 0.002 | 0.6788 |
| L = 65 cm | 0.1887 | 15.826 | 6.2229 | 6.2229 | 0.6348 | 18.12 | 0.1691 | 0.6587 | 0.002 | 0.6801 |
| PR ~ 1.9 | 0.1882 | 14.079 | 6.2964 | 6.2964 | 0.7489 | 16.676 | 0.1691 | 0.66 | 0.002 | 0.6813 |
|  |  |  |  |  |  | 17.641 |  |  |  | 0.6801 |
|  | 0.1617 | 12.56 | 4.4334 | 4.4334 | 0.7378 | 14.059 | 0.1691 | 0.6593 | 0.002 | 0.6807 |
|  | 0.1609 | 12.551 | 4.3586 | 4.3586 | 0.7304 | 14.003 | 0.1691 | 0.6593 | 0.002 | 0.6807 |
|  | 0.1602 | 12.549 | 4.323 | 4.323 | 0.7288 | 13.979 | 0.1691 | 0.6593 | 0.002 | 0.6807 |
|  |  |  |  |  |  | 14.013 |  |  |  | 0.6807 |
|  | 0.1457 | 10.412 | 3.2117 | 3.2117 | 0.7723 | 11.386 | 0.169 | 0.66 | 0.002 | 0.6813 |
|  | 0.1453 | 10.409 | 3.1922 | 3.1922 | 0.7701 | 11.373 | 0.169 | 0.66 | 0.002 | 0.6813 |
|  | 0.1453 | 10.428 | 3.2554 | 3.2554 | 0.788 | 11.428 | 0.169 | 0.66 | 0.002 | 0.6813 |
|  |  |  |  |  |  | 11.396 |  |  |  | 0.6813 |
| f ~ 1200 Hz | 0.1872 | 14.104 | 6.382 | 6.382 | 0.7666 | 16.763 | 0.1691 | 0.6262 | 0.002 | 0.6486 |
| L = 65 cm | 0.1868 | 14.109 | 6.384 | 6.384 | 0.7696 | 16.769 | 0.1691 | 0.6286 | 0.002 | 0.6509 |
| PR ~ 2.0 | 0.1873 | 14.103 | 6.3813 | 6.3813 | 0.7656 | 16.762 | 0.1691 | 0.6262 | 0.002 | 0.6486 |
|  |  |  |  |  |  | 16.765 |  |  |  | 0.6494 |
|  | 0.1614 | 12.564 | 4.4349 | 4.4349 | 0.741 | 14.063 | 0.1691 | 0.6268 | 0.002 | 0.6492 |
|  | 0.1605 | 12.564 | 4.3987 | 4.3987 | 0.7408 | 14.04 | 0.1691 | 0.6286 | 0.002 | 0.6509 |
|  | 0.1597 | 12.555 | 4.3251 | 4.3251 | 0.7334 | 13.986 | 0.1691 | 0.628 | 0.002 | 0.6503 |
|  |  |  |  |  |  | 14.03 |  |  |  | 0.6501 |
|  | 0.1447 | 10.428 | 3.236 | 3.236 | 0.7879 | 11.416 | 0.1689 | 0.6298 | 0.002 | 0.652 |
|  | 0.1442 | 10.429 | 3.2171 | 3.2171 | 0.7885 | 11.406 | 0.1689 | 0.6292 | 0.002 | 0.6515 |
|  | 0.1453 | 10.435 | 3.277 | 3.277 | 0.7939 | 11.446 | 0.1689 | 0.6292 | 0.002 | 0.6515 |
|  |  |  |  |  |  | 11.423 |  |  |  | 0.6517 |

| Experiment Information | Ta (C) | T to (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr/Rs*Rs | Rs/Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 22.1 | 30.3 | 29.6 | 7.53 | 0.08 | 8.2 | 1203 | 1.104 | 218 | 71.63 | 215 | 14 | 0.056 | 0.267 | 0.838 | 3067 | 1953 | 0.005 | 3.881 | 2.0828 | 157.5 |
| L = 65 cm | 22.2 | 30.5 | 29.8 | 7.62 | 0.08 | 8.3 | 1203 | 1.103 | 218 | 71.63 | 215 | 14 | 0.056 | 0.267 | 0.838 | 3067 | 1953 | 0.005 | 3.878 | 2.0809 | 157.5 |
| PR ~ 2.1 | 22.2 | 30.7 | 30 | 7.82 | 0.08 | 8.34 | 1203 | 1.104 | 219 | 70.16 | 215 | 13.7 | 0.056 | 0.267 | 0.839 | 3067 | 1953 | 0.005 | 3.885 | 2.0828 | 157.5 |
|  |  |  |  |  |  |  |  |  |  | 71.14 | 215 | 13.9 | 0.056 | 0.267 | 0.838 | 3067 | 1953 | 0.005 | 3.881 |  |  |
|  | 22.2 | 34.3 | 33.4 | 11.2 | 0.09 | 10.11 | 1203 | 1.104 | 219 | 66.97 | 215 | 13.1 | 0.056 | 0.267 | 0.839 | 3067 | 1953 | 0.007 | 3.885 | 2.0828 | 157.5 |
|  | 22.3 | 34.3 | 33.4 | 11.1 | 0.09 | 10.11 | 1203 | 1.105 | 219 | 67.57 | 216 | 13.2 | 0.056 | 0.267 | 0.84 | 3067 | 1953 | 0.007 | 3.896 | 2.0847 | 157.5 |
|  | 22.3 | 34.6 | 33.7 | 11.4 | 0.09 | 10.25 | 1203 | 1.101 | 217 | 66.78 | 214 | 13 | 0.056 | 0.266 | 0.836 | 3067 | 1953 | 0.007 | 3.867 | 2.0771 | 157.4 |
|  |  |  |  |  |  |  |  |  |  | 67.11 | 215 | 13.1 | 0.056 | 0.267 | 0.838 | 3067 | 1953 | 0.007 | 3.883 |  |  |
|  | 22.6 | 39.1 | 37.8 | 15.2 | 0.11 | 12 | 1203 | 1.103 | 218 | 71.63 | 216 | 14 | 0.056 | 0.267 | 0.838 | 3067 | 1953 | 0.009 | 3.892 | 2.0809 | 157.5 |
|  | 22.6 | 39.1 | 37.7 | 15.1 | 0.11 | 12.04 | 1203 | 1.104 | 219 | 71.89 | 216 | 14 | 0.056 | 0.267 | 0.839 | 3067 | 1953 | 0.009 | 3.899 | 2.0828 | 157.5 |
|  | 22.6 | 38.9 | 37.6 | 15 | 0.11 | 11.91 | 1204 | 1.103 | 218 | 71.99 | 215 | 14.1 | 0.056 | 0.267 | 0.838 | 3070 | 1954 | 0.009 | 3.876 | 2.0809 | 157.5 |
|  |  |  |  |  |  |  |  |  |  | 71.83 | 215 | 14 | 0.056 | 0.267 | 0.838 | 3068 | 1953 | 0.009 | 3.889 |  |  |
| f ~ 1200 Hz | 22.4 | 30.4 | 29.7 | 7.34 | 0.08 | 8.12 | 1204 | 1.155 | 239 | 72.8 | 235 | 14.2 | 0.056 | 0.279 | 0.877 | 3070 | 1954 | 0.004 | 4.242 | 2.179 | 157.9 |
| L = 65 cm | 22.4 | 30.5 | 29.8 | 7.44 | 0.08 | 8.12 | 1204 | 1.154 | 239 | 71.82 | 235 | 14 | 0.056 | 0.279 | 0.876 | 3070 | 1954 | 0.004 | 4.235 | 2.1771 | 157.8 |
| PR ~ 2.2 | 22.4 | 30.6 | 29.9 | 7.53 | 0.08 | 8.25 | 1204 | 1.154 | 239 | 72.1 | 235 | 14.1 | 0.056 | 0.279 | 0.876 | 3070 | 1954 | 0.004 | 4.235 | 2.1771 | 157.8 |
|  |  |  |  |  |  |  |  |  |  | 72.24 | 235 | 14.1 | 0.056 | 0.279 | 0.876 | 3070 | 1954 | 0.004 | 4.237 |  |  |
|  | 22.5 | 34.3 | 33.4 | 10.9 | 0.09 | 10.14 | 1203 | 1.156 | 240 | 69.04 | 237 | 13.5 | 0.056 | 0.28 | 0.879 | 3067 | 1953 | 0.005 | 4.271 | 2.1809 | 157.9 |
|  | 22.6 | 34.5 | 33.6 | 11 | 0.09 | 10.25 | 1203 | 1.154 | 239 | 69.22 | 236 | 13.5 | 0.056 | 0.279 | 0.877 | 3067 | 1953 | 0.006 | 4.26 | 2.1771 | 157.8 |
|  | 22.6 | 34.7 | 33.7 | 11.1 | 0.09 | 10.36 | 1203 | 1.155 | 240 | 68.77 | 236 | 13.4 | 0.056 | 0.279 | 0.878 | 3067 | 1953 | 0.006 | 4.268 | 2.179 | 157.9 |
|  |  |  |  |  |  |  |  |  |  | 69.01 | 236 | 13.5 | 0.056 | 0.279 | 0.878 | 3067 | 1953 | 0.006 | 4.266 |  |  |
|  | 22.7 | 38.6 | 37.2 | 14.5 | 0.11 | 12.12 | 1203 | 1.157 | 240 | 75.39 | 237 | 14.7 | 0.056 | 0.28 | 0.88 | 3067 | 1953 | 0.007 | 4.286 | 2.1828 | 157.9 |
|  | 22.8 | 38.9 | 37.5 | 14.7 | 0.11 | 12.26 | 1203 | 1.158 | 241 | 75.31 | 238 | 14.7 | 0.056 | 0.28 | 0.881 | 3067 | 1953 | 0.007 | 4.298 | 2.1847 | 157.9 |
|  | 22.8 | 38.9 | 37.5 | 14.7 | 0.11 | 12.21 | 1203 | 1.159 | 241 | 74.97 | 238 | 14.6 | 0.056 | 0.281 | 0.881 | 3067 | 1953 | 0.007 | 4.305 | 2.1865 | 157.9 |
|  |  |  |  |  |  |  |  |  |  | 75.23 | 238 | 14.7 | 0.056 | 0.28 | 0.88 | 3067 | 1953 | 0.007 | 4.296 |  |  |
| f ~ 725 | 20.9 | 27.7 | 27.3 | 6.41 | 0.06 | 6.43 | 725 | 0.506 | 75.8 | 49.52 | 75.1 | 9.67 | 0.034 | 0.203 | 0.636 | 1848 | 1177 | 0.035 | 1.747 | 0.9546 | 150.7 |
| L = 60 cm | 20.9 | 28.4 | 28 | 7.09 | 0.06 | 6.74 | 725 | 0.507 | 76.1 | 46.92 | 75.4 | 9.17 | 0.034 | 0.203 | 0.638 | 1848 | 1177 | 0.038 | 1.754 | 0.9565 | 150.7 |
| PR ~ 0.9 | 20.9 | 28.3 | 27.9 | 6.99 | 0.06 | 6.67 | 725 | 0.506 | 75.8 | 47.07 | 75.1 | 9.2 | 0.034 | 0.203 | 0.636 | 1848 | 1177 | 0.038 | 1.747 | 0.9546 | 150.7 |
|  |  |  |  |  |  |  |  |  |  | 47.83 | 75.2 | 9.35 | 0.034 | 0.203 | 0.637 | 1848 | 1177 | 0.037 | 1.75 |  |  |
|  | 21.3 | 33.3 | 32.6 | 11.3 | 0.08 | 8.64 | 725 | 0.506 | 75.9 | 50.32 | 75.3 | 9.83 | 0.034 | 0.203 | 0.637 | 1848 | 1177 | 0.059 | 1.751 | 0.9546 | 150.7 |
|  | 21.3 | 33.6 | 32.9 | 11.6 | 0.08 | 8.86 | 725 | 0.506 | 75.9 | 50.34 | 75.3 | 9.84 | 0.034 | 0.203 | 0.637 | 1848 | 1177 | 0.061 | 1.751 | 0.9546 | 150.7 |
|  | 21.3 | 33.9 | 33.2 | 11.9 | 0.08 | 9.11 | 725 | 0.506 | 75.9 | 50.54 | 75.3 | 9.88 | 0.034 | 0.203 | 0.637 | 1848 | 1177 | 0.062 | 1.751 | 0.9546 | 150.7 |
|  |  |  |  |  |  |  |  |  |  | 50.4 | 75.3 | 9.85 | 0.034 | 0.203 | 0.637 | 1848 | 1177 | 0.061 | 1.751 |  |  |
|  | 21.4 | 36.9 | 36 | 14.6 | 0.09 | 10.08 | 726 | 0.507 | 76.2 | 51.18 | 75.4 | 10 | 0.034 | 0.203 | 0.637 | 1851 | 1178 | 0.076 | 1.752 | 0.9565 | 150.7 |
|  | 21.5 | 37.3 | 36.4 | 14.9 | 0.09 | 10.22 | 726 | 0.507 | 76.2 | 50.89 | 75.4 | 9.94 | 0.034 | 0.203 | 0.637 | 1851 | 1178 | 0.077 | 1.753 | 0.9565 | 150.7 |
|  | 21.6 | 37.6 | 36.7 | 15.1 | 0.09 | 10.32 | 726 | 0.508 | 75.9 | 50.74 | 75.2 | 9.91 | 0.034 | 0.203 | 0.636 | 1851 | 1178 | 0.078 | 1.747 | 0.9546 | 150.7 |
|  |  |  |  |  |  |  |  |  |  | 50.94 | 75.3 | 9.95 | 0.034 | 0.203 | 0.637 | 1851 | 1178 | 0.077 | 1.751 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 1200 Hz | 0.1872 | 14.154 | 6.639 | 6.639 | 0.8013 | 17.005 | 0.1693 | 0.5978 | 0.002 | 0.6214 |
| L = 65 cm | 0.1856 | 14.154 | 6.559 | 6.559 | 0.8013 | 16.943 | 0.1693 | 0.5984 | 0.002 | 0.6219 |
| PR ~ 2.1 | 0.1847 | 14.131 | 6.394 | 6.394 | 0.785 | 16.796 | 0.1693 | 0.5978 | 0.002 | 0.6213 |
|  |  |  |  |  |  | 16.914 |  |  |  | 0.6215 |
|  | 0.1613 | 12.575 | 4.4753 | 4.4753 | 0.7493 | 14.099 | 0.1693 | 0.5978 | 0.002 | 0.6213 |
|  | 0.1614 | 12.584 | 4.5157 | 4.5157 | 0.756 | 14.133 | 0.1692 | 0.5973 | 0.002 | 0.6208 |
|  | 0.1598 | 12.572 | 4.4016 | 4.4016 | 0.7471 | 14.05 | 0.1692 | 0.5995 | 0.002 | 0.6229 |
|  |  |  |  |  |  | 14.094 |  |  |  | 0.6217 |
|  | 0.1452 | 10.442 | 3.2994 | 3.2994 | 0.8013 | 11.466 | 0.1691 | 0.5984 | 0.002 | 0.6218 |
|  | 0.1449 | 10.446 | 3.3003 | 3.3003 | 0.8043 | 11.47 | 0.1691 | 0.5978 | 0.002 | 0.6213 |
|  | 0.1459 | 10.447 | 3.3412 | 3.3412 | 0.8054 | 11.495 | 0.1691 | 0.5984 | 0.002 | 0.6218 |
|  |  |  |  |  |  | 11.477 |  |  |  | 0.6216 |
| f ~ 1200 Hz | 0.1888 | 14.173 | 6.814 | 6.814 | 0.8145 | 17.159 | 0.1692 | 0.5714 | 0.002 | 0.5959 |
| L = 65 cm | 0.1886 | 14.157 | 6.7224 | 6.7224 | 0.8035 | 17.073 | 0.1692 | 0.5719 | 0.002 | 0.5964 |
| PR ~ 2.2 | 0.1865 | 14.162 | 6.6426 | 6.6426 | 0.8067 | 17.015 | 0.1692 | 0.5719 | 0.002 | 0.5964 |
|  |  |  |  |  |  | 17.082 |  |  |  | 0.5963 |
|  | 0.1613 | 12.605 | 4.5999 | 4.5999 | 0.7724 | 14.206 | 0.1691 | 0.5709 | 0.002 | 0.5955 |
|  | 0.1602 | 12.607 | 4.5622 | 4.5622 | 0.7744 | 14.184 | 0.1691 | 0.5719 | 0.002 | 0.5964 |
|  | 0.159 | 12.601 | 4.4845 | 4.4845 | 0.7694 | 14.129 | 0.1691 | 0.5714 | 0.002 | 0.5959 |
|  |  |  |  |  |  | 14.173 |  |  |  | 0.5959 |
|  | 0.1449 | 10.487 | 3.4386 | 3.4386 | 0.8435 | 11.592 | 0.169 | 0.5704 | 0.002 | 0.595 |
|  | 0.1438 | 10.486 | 3.3955 | 3.3955 | 0.8426 | 11.565 | 0.1689 | 0.5699 | 0.002 | 0.5945 |
|  | 0.1442 | 10.482 | 3.3942 | 3.3942 | 0.8388 | 11.56 | 0.1689 | 0.5695 | 0.002 | 0.594 |
|  |  |  |  |  |  | 11.572 |  |  |  | 0.5945 |
| f ~ 725 | 0.2181 | 18.22 | 7.8043 | 7.8043 | 0.554 | 21.311 | 0.17 | 1.3043 | 0.002 | 1.3154 |
| L = 60 cm | 0.2099 | 18.165 | 7.0544 | 7.0544 | 0.5249 | 20.732 | 0.17 | 1.3018 | 0.002 | 1.3128 |
| PR ~ 0.9 | 0.2116 | 18.168 | 7.151 | 7.151 | 0.5266 | 20.801 | 0.17 | 1.3043 | 0.002 | 1.3154 |
|  |  |  |  |  |  | 20.948 |  |  |  | 1.3145 |
|  | 0.1761 | 13.811 | 4.4266 | 4.4266 | 0.563 | 15.175 | 0.1698 | 1.3043 | 0.002 | 1.3154 |
|  | 0.173 | 13.811 | 4.3187 | 4.3187 | 0.5632 | 15.113 | 0.1698 | 1.3043 | 0.002 | 1.3154 |
|  | 0.1698 | 13.815 | 4.2169 | 4.2169 | 0.5655 | 15.058 | 0.1698 | 1.3043 | 0.002 | 1.3154 |
|  |  |  |  |  |  | 15.115 |  |  |  | 1.3154 |
|  | 0.1587 | 12.348 | 3.4305 | 3.4305 | 0.5726 | 13.28 | 0.1698 | 1.3018 | 0.002 | 1.3128 |
|  | 0.1572 | 12.344 | 3.3642 | 3.3642 | 0.5694 | 13.242 | 0.1697 | 1.3018 | 0.002 | 1.3128 |
|  | 0.1561 | 12.341 | 3.3216 | 3.3216 | 0.5677 | 13.218 | 0.1696 | 1.3043 | 0.002 | 1.3153 |
|  |  |  |  |  |  | 13.247 |  |  |  | 1.3136 |

| Experiment Information | Ta (C) | Tc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | $\frac{Gr}{Rs*Rs}$ | $\frac{Rs}{\Lambda}$ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 725 | 21.4 | 29.6 | 29.1 | 7.69 | 0.07 | 7.1 | 726 | 0.554 | 90.9 | 53.12 | 90 | 10.4 | 0.034 | 0.222 | 0.696 | 1851 | 1178 | 0.028 | 2.092 | 1.0452 | 151.5 |
| L = 60 cm | 21.5 | 30 | 29.5 | 7.97 | 0.07 | 7.37 | 726 | 0.554 | 91 | 53.2 | 90.1 | 10.4 | 0.034 | 0.222 | 0.696 | 1851 | 1178 | 0.029 | 2.093 | 1.0452 | 151.5 |
| PR ~ 1.0 | 21.4 | 29.8 | 29.3 | 7.88 | 0.07 | 7.27 | 726 | 0.554 | 90.9 | 53.1 | 90 | 10.4 | 0.034 | 0.222 | 0.696 | 1851 | 1178 | 0.029 | 2.092 | 1.0452 | 151.5 |
| | | | | | | | | | | 53.14 | 90 | 10.4 | 0.034 | 0.222 | 0.696 | 1851 | 1178 | 0.029 | 2.092 | | |
| | 21.5 | 33.7 | 33 | 11.5 | 0.08 | 9.05 | 726 | 0.555 | 91.3 | 51.94 | 90.4 | 10.1 | 0.034 | 0.222 | 0.698 | 1851 | 1178 | 0.041 | 2.101 | 1.0471 | 151.5 |
| | 21.5 | 33.8 | 33.1 | 11.6 | 0.08 | 9.11 | 726 | 0.556 | 91.6 | 51.86 | 90.7 | 10.1 | 0.034 | 0.222 | 0.699 | 1851 | 1178 | 0.042 | 2.108 | 1.0489 | 151.5 |
| | 21.6 | 33.9 | 33.2 | 11.6 | 0.08 | 9.14 | 726 | 0.556 | 91.7 | 52.04 | 90.8 | 10.2 | 0.034 | 0.223 | 0.699 | 1851 | 1178 | 0.041 | 2.11 | 1.0489 | 151.5 |
| | | | | | | | | | | 51.94 | 90.6 | 10.1 | 0.034 | 0.222 | 0.699 | 1851 | 1178 | 0.041 | 2.106 | | |
| | 21.6 | 37.9 | 36.8 | 15.2 | 0.1 | 10.69 | 726 | 0.555 | 91.3 | 57.79 | 90.4 | 11.3 | 0.034 | 0.222 | 0.698 | 1851 | 1178 | 0.055 | 2.102 | 1.0471 | 151.5 |
| | 21.6 | 38 | 36.9 | 15.3 | 0.1 | 10.74 | 726 | 0.556 | 91.7 | 57.7 | 90.8 | 11.3 | 0.034 | 0.223 | 0.699 | 1851 | 1178 | 0.055 | 2.11 | 1.0489 | 151.5 |
| | 21.7 | 38.1 | 37 | 15.3 | 0.1 | 10.89 | 726 | 0.551 | 90.1 | 58.57 | 89.2 | 11.4 | 0.034 | 0.221 | 0.693 | 1851 | 1178 | 0.056 | 2.073 | 1.0395 | 151.4 |
| | | | | | | | | | | 58.02 | 90.1 | 11.3 | 0.034 | 0.222 | 0.697 | 1851 | 1178 | 0.055 | 2.095 | | |
| f ~ 725 | 21.4 | 29.8 | 29.3 | 7.88 | 0.07 | 7.35 | 726 | 0.603 | 108 | 53.72 | 107 | 10.5 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.021 | 2.478 | 1.1376 | 152.2 |
| L = 60 cm | 21.4 | 30 | 29.5 | 8.07 | 0.07 | 7.39 | 726 | 0.603 | 108 | 52.69 | 107 | 10.3 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.021 | 2.478 | 1.1376 | 152.2 |
| PR ~ 1.1 | 21.4 | 30 | 29.5 | 8.07 | 0.07 | 7.43 | 726 | 0.603 | 108 | 53 | 107 | 10.4 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.021 | 2.478 | 1.1376 | 152.2 |
| | | | | | | | | | | 53.14 | 107 | 10.4 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.021 | 2.478 | | |
| | 21.4 | 33.7 | 33 | 11.6 | 0.08 | 9.12 | 726 | 0.603 | 108 | 51.92 | 107 | 10.1 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.03 | 2.478 | 1.1376 | 152.2 |
| | 21.5 | 33.6 | 32.9 | 11.4 | 0.08 | 9.06 | 726 | 0.603 | 108 | 52.46 | 107 | 10.2 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.03 | 2.48 | 1.1376 | 152.2 |
| | 21.5 | 33.3 | 32.6 | 11.1 | 0.08 | 8.95 | 726 | 0.603 | 108 | 53.19 | 107 | 10.4 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.029 | 2.48 | 1.1376 | 152.2 |
| | | | | | | | | | | 52.52 | 107 | 10.3 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.029 | 2.479 | | |
| | 21.6 | 38.1 | 37 | 15.4 | 0.1 | 10.85 | 726 | 0.603 | 108 | 57.96 | 107 | 11.3 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.04 | 2.481 | 1.1376 | 152.2 |
| | 21.6 | 38.1 | 37 | 15.4 | 0.1 | 10.89 | 726 | 0.603 | 108 | 58.19 | 107 | 11.4 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.04 | 2.481 | 1.1376 | 152.2 |
| | 21.6 | 37.9 | 36.8 | 15.2 | 0.1 | 10.82 | 726 | 0.603 | 108 | 58.55 | 107 | 11.4 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.039 | 2.481 | 1.1376 | 152.2 |
| | | | | | | | | | | 58.23 | 107 | 11.4 | 0.034 | 0.241 | 0.758 | 1851 | 1178 | 0.04 | 2.481 | | |
| f ~ 725 | 21.5 | 29.8 | 29.3 | 7.77 | 0.07 | 7.43 | 726 | 0.654 | 127 | 55.04 | 126 | 10.8 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.015 | 2.917 | 1.2338 | 152.9 |
| L = 60 cm | 21.5 | 30 | 29.5 | 7.96 | 0.07 | 7.56 | 726 | 0.654 | 127 | 54.66 | 126 | 10.7 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.015 | 2.917 | 1.2338 | 152.9 |
| PR ~ 1.2 | 21.5 | 29.8 | 29.3 | 7.77 | 0.07 | 7.42 | 726 | 0.654 | 127 | 54.96 | 126 | 10.7 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.015 | 2.917 | 1.2338 | 152.9 |
| | | | | | | | | | | 54.89 | 126 | 10.7 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.015 | 2.917 | | |
| | 21.5 | 33.7 | 32.8 | 11.3 | 0.09 | 9.31 | 726 | 0.654 | 127 | 60.73 | 126 | 11.9 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.021 | 2.917 | 1.2338 | 152.9 |
| | 21.6 | 34 | 33.1 | 11.5 | 0.09 | 9.4 | 726 | 0.654 | 127 | 60.3 | 126 | 11.8 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.022 | 2.919 | 1.2338 | 152.9 |
| | 21.6 | 34 | 33.1 | 11.5 | 0.09 | 9.4 | 726 | 0.654 | 127 | 60.3 | 126 | 11.8 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.022 | 2.919 | 1.2338 | 152.9 |
| | | | | | | | | | | 60.44 | 126 | 11.8 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.021 | 2.918 | | |
| | 21.6 | 37.9 | 36.8 | 15.2 | 0.1 | 10.92 | 726 | 0.654 | 127 | 59.13 | 126 | 11.6 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.028 | 2.919 | 1.2338 | 152.9 |
| | 21.6 | 37.9 | 36.8 | 15.2 | 0.1 | 10.87 | 726 | 0.654 | 127 | 58.84 | 126 | 11.5 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.028 | 2.919 | 1.2338 | 152.9 |
| | 21.6 | 37.7 | 36.6 | 15 | 0.1 | 10.8 | 726 | 0.654 | 127 | 59.21 | 126 | 11.6 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.028 | 2.919 | 1.2338 | 152.9 |
| | | | | | | | | | | 59.06 | 126 | 11.5 | 0.034 | 0.262 | 0.822 | 1851 | 1178 | 0.028 | 2.919 | | |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 725 | 0.2034 | 15.759 | 6.4991 | 6.4991 | 0.5943 | 18.255 | 0.1698 | 1.1913 | 0.002 | 1.2034 |
| L = 60 cm | 0.1979 | 15.761 | 6.2703 | 6.2703 | 0.5952 | 18.095 | 0.1697 | 1.1913 | 0.002 | 1.2034 |
| PR ~ 1.0 | 0.1999 | 15.759 | 6.3442 | 6.3442 | 0.5941 | 18.145 | 0.1698 | 1.1913 | 0.002 | 1.2034 |
|  |  |  |  |  |  | 18.165 |  |  |  | 1.2034 |
|  | 0.1708 | 13.837 | 4.3622 | 4.3622 | 0.5811 | 15.162 | 0.1697 | 1.1892 | 0.002 | 1.2012 |
|  | 0.17 | 13.836 | 4.3264 | 4.3264 | 0.5802 | 15.14 | 0.1697 | 1.1871 | 0.002 | 1.1991 |
|  | 0.1697 | 13.839 | 4.3273 | 4.3273 | 0.5822 | 15.143 | 0.1696 | 1.1871 | 0.002 | 1.1991 |
|  |  |  |  |  |  | 15.149 |  |  |  | 1.1998 |
|  | 0.1538 | 11.252 | 3.2872 | 3.2872 | 0.6466 | 12.193 | 0.1696 | 1.1892 | 0.002 | 1.2012 |
|  | 0.1533 | 11.251 | 3.2669 | 3.2669 | 0.6456 | 12.181 | 0.1696 | 1.1871 | 0.002 | 1.1991 |
|  | 0.1521 | 11.262 | 3.2701 | 3.2701 | 0.6553 | 12.193 | 0.1696 | 1.1978 | 0.002 | 1.2098 |
|  |  |  |  |  |  | 12.189 |  |  |  | 1.2034 |
| f ~ 725 | 0.1984 | 15.77 | 6.3488 | 6.3488 | 0.601 | 18.158 | 0.1698 | 1.0945 | 0.002 | 1.1076 |
| L = 60 cm | 0.1974 | 15.752 | 6.1937 | 6.1937 | 0.5895 | 18.034 | 0.1698 | 1.0945 | 0.002 | 1.1076 |
| PR ~ 1.1 | 0.1967 | 15.757 | 6.1959 | 6.1959 | 0.5929 | 18.04 | 0.1698 | 1.0945 | 0.002 | 1.1076 |
|  |  |  |  |  |  | 18.077 |  |  |  | 1.1076 |
|  | 0.1699 | 13.837 | 4.3267 | 4.3267 | 0.5808 | 15.141 | 0.1698 | 1.0945 | 0.002 | 1.1076 |
|  | 0.1708 | 13.845 | 4.401 | 4.401 | 0.5869 | 15.192 | 0.1697 | 1.0945 | 0.002 | 1.1076 |
|  | 0.1724 | 13.857 | 4.5167 | 4.5167 | 0.595 | 15.271 | 0.1697 | 1.0945 | 0.002 | 1.1076 |
|  |  |  |  |  |  | 15.202 |  |  |  | 1.1076 |
|  | 0.1524 | 11.254 | 3.248 | 3.248 | 0.6484 | 12.174 | 0.1696 | 1.0945 | 0.002 | 1.1076 |
|  | 0.1521 | 11.257 | 3.2489 | 3.2489 | 0.651 | 12.177 | 0.1696 | 1.0945 | 0.002 | 1.1076 |
|  | 0.1528 | 11.262 | 3.2901 | 3.2901 | 0.655 | 12.204 | 0.1696 | 1.0945 | 0.002 | 1.1076 |
|  |  |  |  |  |  | 12.185 |  |  |  | 1.1076 |
| f ~ 725 | 0.1972 | 15.795 | 6.4351 | 6.4351 | 0.6158 | 18.24 | 0.1697 | 1.0092 | 0.002 | 1.0233 |
| L = 60 cm | 0.1946 | 15.788 | 6.281 | 6.281 | 0.6116 | 18.126 | 0.1697 | 1.0092 | 0.002 | 1.0233 |
| PR ~ 1.2 | 0.1974 | 15.793 | 6.4346 | 6.4346 | 0.6149 | 18.239 | 0.1697 | 1.0092 | 0.002 | 1.0233 |
|  |  |  |  |  |  | 18.202 |  |  |  | 1.0233 |
|  | 0.1693 | 12.485 | 4.4069 | 4.4069 | 0.6794 | 13.972 | 0.1697 | 1.0092 | 0.002 | 1.0233 |
|  | 0.1681 | 12.479 | 4.3337 | 4.3337 | 0.6746 | 13.92 | 0.1696 | 1.0092 | 0.002 | 1.0233 |
|  | 0.1681 | 12.479 | 4.3337 | 4.3337 | 0.6746 | 13.92 | 0.1696 | 1.0092 | 0.002 | 1.0233 |
|  |  |  |  |  |  | 13.937 |  |  |  | 1.0233 |
|  | 0.152 | 11.27 | 3.2923 | 3.2923 | 0.6615 | 12.212 | 0.1696 | 1.0092 | 0.002 | 1.0233 |
|  | 0.1524 | 11.266 | 3.2912 | 3.2912 | 0.6583 | 12.208 | 0.1696 | 1.0092 | 0.002 | 1.0233 |
|  | 0.1531 | 11.271 | 3.3335 | 3.3335 | 0.6624 | 12.236 | 0.1696 | 1.0092 | 0.002 | 1.0233 |
|  |  |  |  |  |  | 12.219 |  |  |  | 1.0233 |

| Experiment Information | Ta (C) | Ttc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | Corr h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr / Rs*Rs | Rs / Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 725 | 21.5 | 29.4 | 28.9 | 7.38 | 0.07 | 7.35 | 726 | 0.704 | 147 | 57.36 | 145 | 11.2 | 0.034 | 0.282 | 0.885 | 1851 | 1178 | 0.01 | 3.38 | 1.3282 | 153.6 |
| L = 60 cm | 21.5 | 29.2 | 28.7 | 7.18 | 0.07 | 7.24 | 726 | 0.703 | 146 | 58.01 | 145 | 11.3 | 0.034 | 0.281 | 0.884 | 1851 | 1178 | 0.01 | 3.371 | 1.3263 | 153.5 |
| PR ~ 1.3 | 21.5 | 29.6 | 29.1 | 7.56 | 0.07 | 7.58 | 726 | 0.703 | 146 | 57.72 | 145 | 11.3 | 0.034 | 0.281 | 0.884 | 1851 | 1178 | 0.011 | 3.371 | 1.3263 | 153.5 |
|  |  |  |  |  |  |  |  |  |  | 57.7 | 145 | 11.3 | 0.034 | 0.281 | 0.884 | 1851 | 1178 | 0.01 | 3.374 |  |  |
|  | 21.5 | 33.4 | 32.5 | 11 | 0.09 | 9.41 | 726 | 0.704 | 147 | 63.1 | 145 | 12.3 | 0.034 | 0.282 | 0.885 | 1851 | 1178 | 0.015 | 3.38 | 1.3282 | 153.6 |
|  | 21.5 | 33.9 | 33 | 11.5 | 0.09 | 9.61 | 726 | 0.704 | 147 | 61.75 | 145 | 12.1 | 0.034 | 0.282 | 0.885 | 1851 | 1178 | 0.016 | 3.38 | 1.3282 | 153.6 |
|  | 21.6 | 33.8 | 32.9 | 11.3 | 0.09 | 9.51 | 726 | 0.704 | 147 | 62.13 | 146 | 12.1 | 0.034 | 0.282 | 0.885 | 1851 | 1178 | 0.016 | 3.382 | 1.3282 | 153.6 |
|  |  |  |  |  |  |  |  |  |  | 62.33 | 145 | 12.2 | 0.034 | 0.282 | 0.885 | 1851 | 1178 | 0.016 | 3.381 |  |  |
|  | 21.7 | 37.4 | 36.3 | 14.6 | 0.1 | 10.8 | 726 | 0.704 | 147 | 60.83 | 146 | 11.9 | 0.034 | 0.282 | 0.885 | 1851 | 1178 | 0.02 | 3.384 | 1.3282 | 153.6 |
|  | 21.7 | 37.2 | 36.1 | 14.4 | 0.1 | 10.7 | 726 | 0.704 | 147 | 61.06 | 146 | 11.9 | 0.034 | 0.282 | 0.885 | 1851 | 1178 | 0.02 | 3.384 | 1.3282 | 153.6 |
|  | 21.7 | 37.8 | 36.7 | 15 | 0.1 | 11 | 726 | 0.704 | 147 | 60.39 | 146 | 11.8 | 0.034 | 0.282 | 0.885 | 1851 | 1178 | 0.021 | 3.384 | 1.3282 | 153.6 |
|  |  |  |  |  |  |  |  |  |  | 60.76 | 146 | 11.9 | 0.034 | 0.282 | 0.885 | 1851 | 1178 | 0.02 | 3.384 |  |  |
| f ~ 725 | 21.7 | 29.6 | 29.1 | 7.36 | 0.07 | 7.56 | 726 | 0.754 | 169 | 59.12 | 167 | 11.6 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.008 | 3.882 | 1.4225 | 154.1 |
| L = 60 cm | 21.7 | 29.8 | 29.3 | 7.55 | 0.07 | 7.67 | 726 | 0.754 | 169 | 58.46 | 167 | 11.4 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.008 | 3.882 | 1.4225 | 154.1 |
| PR ~ 1.4 | 21.8 | 30.1 | 29.5 | 7.75 | 0.07 | 7.73 | 726 | 0.753 | 168 | 57.42 | 167 | 11.2 | 0.034 | 0.301 | 0.947 | 1851 | 1178 | 0.008 | 3.874 | 1.4206 | 154.1 |
|  |  |  |  |  |  |  |  |  |  | 58.33 | 167 | 11.4 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.008 | 3.88 |  |  |
|  | 22 | 34.2 | 33.3 | 11.3 | 0.09 | 9.69 | 726 | 0.753 | 168 | 63.4 | 167 | 12.4 | 0.034 | 0.302 | 0.947 | 1851 | 1178 | 0.012 | 3.879 | 1.4206 | 154.1 |
|  | 22.1 | 34.4 | 33.5 | 11.4 | 0.09 | 9.8 | 726 | 0.753 | 168 | 63.62 | 167 | 12.4 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.012 | 3.881 | 1.4206 | 154.1 |
|  | 22.1 | 34.5 | 33.6 | 11.5 | 0.09 | 9.84 | 726 | 0.753 | 168 | 63.34 | 167 | 12.4 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.012 | 3.881 | 1.4206 | 154.1 |
|  |  |  |  |  |  |  |  |  |  | 63.45 | 167 | 12.4 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.012 | 3.88 |  |  |
|  | 22.3 | 37.8 | 36.7 | 14.4 | 0.1 | 11.07 | 726 | 0.753 | 169 | 63.34 | 167 | 12.4 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.015 | 3.886 | 1.4206 | 154.1 |
|  | 22.3 | 38.1 | 37 | 14.7 | 0.1 | 11.26 | 726 | 0.753 | 169 | 63.19 | 167 | 12.3 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.015 | 3.886 | 1.4206 | 154.1 |
|  | 22.2 | 38.2 | 37 | 14.8 | 0.1 | 11.3 | 726 | 0.753 | 168 | 62.58 | 167 | 12.2 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.015 | 3.883 | 1.4206 | 154.1 |
|  |  |  |  |  |  |  |  |  |  | 63.04 | 167 | 12.3 | 0.034 | 0.302 | 0.948 | 1851 | 1178 | 0.015 | 3.885 |  |  |
| f ~ 725 | 22.2 | 30.2 | 29.6 | 7.44 | 0.07 | 7.8 | 727 | 0.804 | 192 | 60.32 | 190 | 11.8 | 0.034 | 0.322 | 1.011 | 1853 | 1180 | 0.006 | 4.409 | 1.5168 | 154.7 |
| L = 60 cm | 22.2 | 30.3 | 29.7 | 7.54 | 0.07 | 7.83 | 727 | 0.804 | 192 | 59.76 | 190 | 11.7 | 0.034 | 0.322 | 1.011 | 1853 | 1180 | 0.006 | 4.409 | 1.5168 | 154.7 |
| PR ~ 1.5 | 22.2 | 30.2 | 29.6 | 7.45 | 0.07 | 7.72 | 727 | 0.803 | 191 | 59.65 | 189 | 11.7 | 0.034 | 0.321 | 1.009 | 1853 | 1180 | 0.006 | 4.398 | 1.5149 | 154.7 |
|  |  |  |  |  |  |  |  |  |  | 59.91 | 190 | 11.7 | 0.034 | 0.322 | 1.01 | 1853 | 1180 | 0.006 | 4.405 |  |  |
|  | 22.3 | 34.3 | 33.4 | 11.1 | 0.09 | 9.8 | 727 | 0.803 | 191 | 65.33 | 189 | 12.8 | 0.034 | 0.321 | 1.01 | 1853 | 1180 | 0.009 | 4.401 | 1.5149 | 154.7 |
|  | 22.3 | 34.4 | 33.5 | 11.2 | 0.09 | 9.89 | 727 | 0.803 | 191 | 65.39 | 189 | 12.8 | 0.034 | 0.321 | 1.01 | 1853 | 1180 | 0.009 | 4.401 | 1.5149 | 154.7 |
|  | 22.4 | 34.2 | 33.3 | 10.9 | 0.09 | 9.71 | 727 | 0.803 | 191 | 65.87 | 190 | 12.9 | 0.034 | 0.321 | 1.01 | 1853 | 1180 | 0.009 | 4.403 | 1.5149 | 154.7 |
|  |  |  |  |  |  |  |  |  |  | 65.53 | 189 | 12.8 | 0.034 | 0.321 | 1.01 | 1853 | 1180 | 0.009 | 4.401 |  |  |
|  | 22.5 | 37.8 | 36.6 | 14.1 | 0.1 | 11.3 | 727 | 0.803 | 192 | 65.68 | 190 | 12.8 | 0.034 | 0.321 | 1.01 | 1853 | 1180 | 0.011 | 4.406 | 1.5149 | 154.7 |
|  | 22.6 | 38.2 | 37 | 14.4 | 0.1 | 11.42 | 727 | 0.803 | 192 | 65.04 | 190 | 12.7 | 0.034 | 0.322 | 1.01 | 1853 | 1180 | 0.011 | 4.409 | 1.5149 | 154.7 |
|  | 22.6 | 38.9 | 37.6 | 15 | 0.11 | 11.75 | 727 | 0.803 | 192 | 70.94 | 190 | 13.9 | 0.034 | 0.322 | 1.01 | 1853 | 1180 | 0.012 | 4.409 | 1.5149 | 154.7 |
|  |  |  |  |  |  |  |  |  |  | 67.22 | 190 | 13.1 | 0.034 | 0.321 | 1.01 | 1853 | 1180 | 0.011 | 4.408 |  |  |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 725 | 0.1993 | 15.837 | 6.7792 | 6.7792 | 0.6418 | 18.525 | 0.1697 | 0.9375 | 0.002 | 0.9527 |
| L = 60 cm | 0.2017 | 15.849 | 6.9605 | 6.9605 | 0.6491 | 18.67 | 0.1697 | 0.9388 | 0.002 | 0.954 |
| PR ~ 1.3 | 0.1949 | 15.844 | 6.6145 | 6.6145 | 0.6458 | 18.411 | 0.1697 | 0.9388 | 0.002 | 0.954 |
| | | | | | | 18.535 | | | | 0.9536 |
| | 0.1685 | 12.519 | 4.5303 | 4.5303 | 0.706 | 14.082 | 0.1697 | 0.9375 | 0.002 | 0.9527 |
| | 0.1659 | 12.5 | 4.3409 | 4.3409 | 0.6908 | 13.944 | 0.1697 | 0.9375 | 0.002 | 0.9527 |
| | 0.1671 | 12.505 | 4.414 | 4.414 | 0.6951 | 13.995 | 0.1696 | 0.9375 | 0.002 | 0.9527 |
| | | | | | | 14.007 | | | | 0.9527 |
| | 0.1533 | 11.292 | 3.4249 | 3.4249 | 0.6806 | 12.307 | 0.1696 | 0.9375 | 0.002 | 0.9527 |
| | 0.1543 | 11.295 | 3.47 | 3.47 | 0.6832 | 12.335 | 0.1696 | 0.9375 | 0.002 | 0.9527 |
| | 0.1515 | 11.286 | 3.3381 | 3.3381 | 0.6756 | 12.253 | 0.1696 | 0.9375 | 0.002 | 0.9527 |
| | | | | | | 12.298 | | | | 0.9527 |
| f ~ 725 | 0.1956 | 15.869 | 6.793 | 6.793 | 0.6615 | 18.563 | 0.1696 | 0.8753 | 0.002 | 0.8916 |
| L = 60 cm | 0.1934 | 15.857 | 6.6201 | 6.6201 | 0.654 | 18.427 | 0.1696 | 0.8753 | 0.002 | 0.8916 |
| PR ~ 1.4 | 0.1921 | 15.838 | 6.4529 | 6.4529 | 0.6425 | 18.292 | 0.1695 | 0.8765 | 0.002 | 0.8927 |
| | | | | | | 18.427 | | | | 0.892 |
| | 0.1652 | 12.524 | 4.4205 | 4.4205 | 0.7093 | 14.016 | 0.1694 | 0.8765 | 0.002 | 0.8927 |
| | 0.164 | 12.527 | 4.3856 | 4.3856 | 0.7117 | 13.997 | 0.1693 | 0.8765 | 0.002 | 0.8927 |
| | 0.1635 | 12.523 | 4.3489 | 4.3489 | 0.7086 | 13.97 | 0.1693 | 0.8765 | 0.002 | 0.8927 |
| | | | | | | 13.995 | | | | 0.8927 |
| | 0.1514 | 11.324 | 3.4791 | 3.4791 | 0.7086 | 12.368 | 0.1692 | 0.8765 | 0.002 | 0.8927 |
| | 0.1497 | 11.323 | 3.4125 | 3.4125 | 0.707 | 12.329 | 0.1692 | 0.8765 | 0.002 | 0.8927 |
| | 0.1492 | 11.315 | 3.3674 | 3.3674 | 0.7002 | 12.297 | 0.1693 | 0.8765 | 0.002 | 0.8927 |
| | | | | | | 12.331 | | | | 0.8927 |
| f ~ 725 | 0.1915 | 15.891 | 6.7173 | 6.7173 | 0.6749 | 18.528 | 0.1693 | 0.8209 | 0.002 | 0.8382 |
| L = 60 cm | 0.1909 | 15.881 | 6.6302 | 6.6302 | 0.6687 | 18.456 | 0.1693 | 0.8209 | 0.002 | 0.8382 |
| PR ~ 1.5 | 0.1928 | 15.879 | 6.7122 | 6.7122 | 0.6674 | 18.513 | 0.1693 | 0.8219 | 0.002 | 0.8392 |
| | | | | | | 18.499 | | | | 0.8385 |
| | 0.1644 | 12.552 | 4.5041 | 4.5041 | 0.731 | 14.095 | 0.1692 | 0.8219 | 0.002 | 0.8392 |
| | 0.1634 | 12.552 | 4.4672 | 4.4672 | 0.7316 | 14.073 | 0.1692 | 0.8219 | 0.002 | 0.8392 |
| | 0.1655 | 12.559 | 4.5833 | 4.5833 | 0.737 | 14.153 | 0.1692 | 0.8219 | 0.002 | 0.8392 |
| | | | | | | 14.107 | | | | 0.8392 |
| | 0.1498 | 11.355 | 3.534 | 3.534 | 0.7348 | 12.429 | 0.1691 | 0.8219 | 0.002 | 0.8391 |
| | 0.1487 | 11.347 | 3.4635 | 3.4635 | 0.7277 | 12.381 | 0.1691 | 0.8219 | 0.002 | 0.8391 |
| | 0.147 | 10.434 | 3.3372 | 3.3372 | 0.7937 | 11.48 | 0.1691 | 0.8219 | 0.002 | 0.8391 |
| | | | | | | 12.097 | | | | 0.8391 |

| Experiment Information | Ta (C) | Ttc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mid V (mV) | Rs | h W/m^2K | Corr Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Gr Rs*Rs | Rs Λ | PR % | SPL (dB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 725 | 22.5 | 30.4 | 29.8 | 7.34 | 0.07 | 7.91 | 727 | 0.85 | 215 | 62.07 | 213 | 12.1 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.005 | 4.937 | 1.6036 | 155.2 |
| L = 60 cm | 22.5 | 30.5 | 29.9 | 7.43 | 0.07 | 7.98 | 727 | 0.85 | 215 | 61.82 | 213 | 12.1 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.005 | 4.937 | 1.6036 | 155.2 |
| PR ~ 1.6 | 22.5 | 30.3 | 29.7 | 7.24 | 0.07 | 7.84 | 727 | 0.85 | 215 | 62.33 | 213 | 12.2 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.005 | 4.937 | 1.6036 | 155.2 |
| | | | | | | | | | | 62.07 | 213 | 12.1 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.005 | 4.937 | | |
| | 22.5 | 34.7 | 33.8 | 11.3 | 0.09 | 10.22 | 727 | 0.85 | 215 | 67.16 | 213 | 13.1 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.007 | 4.937 | 1.6036 | 155.2 |
| | 22.5 | 34.6 | 33.7 | 11.2 | 0.09 | 10.13 | 727 | 0.85 | 215 | 67.11 | 213 | 13.1 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.007 | 4.937 | 1.6036 | 155.2 |
| | 22.5 | 34.9 | 34 | 11.5 | 0.09 | 10.3 | 727 | 0.85 | 215 | 66.54 | 213 | 13 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.007 | 4.937 | 1.6036 | 155.2 |
| | | | | | | | | | | 66.94 | 213 | 13.1 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.007 | 4.937 | | |
| | 22.7 | 38.6 | 37.3 | 14.6 | 0.11 | 11.86 | 727 | 0.85 | 215 | 73.63 | 213 | 14.4 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.009 | 4.943 | 1.6036 | 155.2 |
| | 22.7 | 38.9 | 37.6 | 14.9 | 0.11 | 11.95 | 727 | 0.85 | 215 | 72.74 | 213 | 14.2 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.009 | 4.943 | 1.6036 | 155.2 |
| | 22.8 | 38.8 | 37.5 | 14.7 | 0.11 | 11.93 | 727 | 0.85 | 215 | 73.6 | 213 | 14.4 | 0.034 | 0.34 | 1.07 | 1853 | 1180 | 0.009 | 4.946 | 1.6036 | 155.2 |
| | | | | | | | | | | 73.32 | 213 | 14.3 | 0.034 | 0.34 | 1.069 | 1853 | 1180 | 0.009 | 4.944 | | |
| f ~ 725 | 22.9 | 30.5 | 29.9 | 7.03 | 0.07 | 7.96 | 728 | 0.901 | 241 | 65.16 | 239 | 12.7 | 0.034 | 0.36 | 1.132 | 1856 | 1182 | 0.003 | 5.537 | 1.6998 | 155.7 |
| L = 60 cm | 22.9 | 30.7 | 30 | 7.13 | 0.08 | 8.2 | 728 | 0.901 | 241 | 75.64 | 239 | 14.8 | 0.034 | 0.36 | 1.132 | 1856 | 1182 | 0.003 | 5.537 | 1.6998 | 155.7 |
| PR ~ 1.7 | 22.9 | 30.6 | 29.9 | 7.03 | 0.08 | 8.17 | 728 | 0.901 | 241 | 76.41 | 239 | 14.9 | 0.034 | 0.36 | 1.132 | 1856 | 1182 | 0.003 | 5.537 | 1.6998 | 155.7 |
| | | | | | | | | | | 72.4 | 239 | 14.1 | 0.034 | 0.36 | 1.132 | 1856 | 1182 | 0.003 | 5.537 | | |
| | 23 | 34.6 | 33.7 | 10.7 | 0.09 | 10.23 | 728 | 0.901 | 241 | 71.01 | 239 | 13.9 | 0.034 | 0.36 | 1.132 | 1856 | 1182 | 0.005 | 5.54 | 1.6998 | 155.7 |
| | 23 | 34.7 | 33.8 | 10.8 | 0.09 | 10.31 | 728 | 0.901 | 241 | 70.95 | 239 | 13.9 | 0.034 | 0.36 | 1.132 | 1856 | 1182 | 0.005 | 5.54 | 1.6998 | 155.7 |
| | 23.1 | 34.9 | 34 | 10.9 | 0.09 | 10.35 | 728 | 0.901 | 241 | 70.59 | 239 | 13.8 | 0.034 | 0.361 | 1.133 | 1856 | 1182 | 0.005 | 5.544 | 1.6998 | 155.7 |
| | | | | | | | | | | 70.85 | 239 | 13.8 | 0.034 | 0.361 | 1.133 | 1856 | 1182 | 0.005 | 5.541 | | |
| | 23.1 | 38.9 | 37.5 | 14.4 | 0.11 | 12.14 | 728 | 0.901 | 241 | 76.05 | 239 | 14.9 | 0.034 | 0.361 | 1.133 | 1856 | 1182 | 0.007 | 5.544 | 1.6998 | 155.7 |
| | 23.2 | 39.2 | 37.8 | 14.6 | 0.11 | 12.26 | 728 | 0.901 | 241 | 75.82 | 239 | 14.8 | 0.034 | 0.361 | 1.133 | 1856 | 1182 | 0.007 | 5.547 | 1.6998 | 155.7 |
| | 23.2 | 39.4 | 38 | 14.8 | 0.11 | 12.34 | 728 | 0.901 | 241 | 75.34 | 239 | 14.7 | 0.034 | 0.361 | 1.133 | 1856 | 1182 | 0.007 | 5.547 | 1.6998 | 155.7 |
| | | | | | | | | | | 75.74 | 239 | 14.8 | 0.034 | 0.361 | 1.133 | 1856 | 1182 | 0.007 | 5.546 | | |
| f ~ 725 | 23.2 | 30.8 | 30.1 | 6.92 | 0.08 | 8.3 | 728 | 0.954 | 271 | 78.87 | 268 | 15.4 | 0.034 | 0.382 | 1.2 | 1856 | 1182 | 0.003 | 6.219 | 1.7998 | 156.2 |
| L = 60 cm | 23.2 | 31 | 30.3 | 7.11 | 0.08 | 8.44 | 728 | 0.954 | 271 | 78.07 | 268 | 15.3 | 0.034 | 0.382 | 1.2 | 1856 | 1182 | 0.003 | 6.219 | 1.7998 | 156.2 |
| PR ~ 1.8 | 23.1 | 31 | 30.3 | 7.21 | 0.08 | 8.5 | 728 | 0.954 | 270 | 77.59 | 268 | 15.2 | 0.034 | 0.382 | 1.199 | 1856 | 1182 | 0.003 | 6.215 | 1.7998 | 156.2 |
| | | | | | | | | | | 78.18 | 268 | 15.3 | 0.034 | 0.382 | 1.199 | 1856 | 1182 | 0.003 | 6.217 | | |
| | 23.3 | 35.2 | 34.1 | 10.8 | 0.1 | 10.64 | 728 | 0.953 | 270 | 80.9 | 268 | 15.8 | 0.034 | 0.381 | 1.198 | 1856 | 1182 | 0.004 | 6.209 | 1.7979 | 156.2 |
| | 23.3 | 35.4 | 34.3 | 11 | 0.1 | 10.73 | 728 | 0.952 | 270 | 80.17 | 267 | 15.7 | 0.034 | 0.381 | 1.197 | 1856 | 1182 | 0.004 | 6.196 | 1.796 | 156.2 |
| | 23.4 | 35.7 | 34.6 | 11.2 | 0.1 | 10.85 | 728 | 0.952 | 270 | 79.7 | 267 | 15.6 | 0.034 | 0.381 | 1.197 | 1856 | 1182 | 0.004 | 6.2 | 1.796 | 156.2 |
| | | | | | | | | | | 80.26 | 267 | 15.7 | 0.034 | 0.381 | 1.198 | 1856 | 1182 | 0.004 | 6.202 | | |
| | 23.4 | 39.2 | 37.8 | 14.4 | 0.11 | 12.44 | 728 | 0.952 | 270 | 78.11 | 267 | 15.3 | 0.034 | 0.381 | 1.197 | 1856 | 1182 | 0.005 | 6.2 | 1.796 | 156.2 |
| | 23.5 | 39.6 | 38.2 | 14.7 | 0.11 | 12.61 | 728 | 0.952 | 270 | 77.67 | 267 | 15.2 | 0.034 | 0.381 | 1.198 | 1856 | 1182 | 0.006 | 6.204 | 1.796 | 156.2 |
| | 23.6 | 39.5 | 38.1 | 14.5 | 0.11 | 12.56 | 728 | 0.952 | 270 | 78.4 | 267 | 15.3 | 0.034 | 0.381 | 1.198 | 1856 | 1182 | 0.005 | 6.208 | 1.796 | 156.2 |
| | | | | | | | | | | 78.06 | 267 | 15.3 | 0.034 | 0.381 | 1.198 | 1856 | 1182 | 0.006 | 6.204 | | |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Req uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 725 | 0.19 | 15.923 | 6.8161 | 6.8161 | 0.6944 | 18.628 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| L = 60 cm | 0.1887 | 15.919 | 6.7289 | 6.7289 | 0.6916 | 18.56 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| PR ~ 1.6 | 0.1913 | 15.928 | 6.9055 | 6.9055 | 0.6973 | 18.698 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| | | | | | | 18.628 | | | | 0.7947 |
| | 0.1602 | 12.578 | 4.4396 | 4.4396 | 0.7514 | 14.079 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| | 0.1611 | 12.577 | 4.476 | 4.476 | 0.7509 | 14.101 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| | 0.1592 | 12.569 | 4.3649 | 4.3649 | 0.7445 | 14.024 | 0.1691 | 0.7765 | 0.002 | 0.7947 |
| | | | | | | 14.068 | | | | 0.7947 |
| | 0.1466 | 10.466 | 3.4317 | 3.4317 | 0.8238 | 11.567 | 0.169 | 0.7765 | 0.002 | 0.7947 |
| | 0.1457 | 10.456 | 3.3647 | 3.3647 | 0.8138 | 11.517 | 0.169 | 0.7765 | 0.002 | 0.7947 |
| | 0.146 | 10.466 | 3.4101 | 3.4101 | 0.8234 | 11.554 | 0.1689 | 0.7765 | 0.002 | 0.7946 |
| | | | | | | 11.546 | | | | 0.7946 |
| f ~ 725 | 0.1898 | 15.98 | 7.1103 | 7.1103 | 0.729 | 18.896 | 0.1689 | 0.7325 | 0.002 | 0.7517 |
| L = 60 cm | 0.1881 | 14.219 | 7.0113 | 7.0113 | 0.8463 | 17.357 | 0.1689 | 0.7325 | 0.002 | 0.7517 |
| PR ~ 1.7 | 0.1887 | 14.231 | 7.1086 | 7.1086 | 0.8549 | 17.446 | 0.1689 | 0.7325 | 0.002 | 0.7517 |
| | | | | | | 17.899 | | | | 0.7517 |
| | 0.1608 | 12.633 | 4.6898 | 4.6898 | 0.7945 | 14.291 | 0.1688 | 0.7325 | 0.002 | 0.7517 |
| | 0.1599 | 12.632 | 4.6494 | 4.6494 | 0.7938 | 14.264 | 0.1688 | 0.7325 | 0.002 | 0.7517 |
| | 0.1594 | 12.627 | 4.6081 | 4.6081 | 0.7898 | 14.233 | 0.1688 | 0.7325 | 0.002 | 0.7517 |
| | | | | | | 14.263 | | | | 0.7517 |
| | 0.1449 | 10.495 | 3.4629 | 3.4629 | 0.8509 | 11.614 | 0.1688 | 0.7325 | 0.002 | 0.7517 |
| | 0.1439 | 10.492 | 3.4187 | 3.4187 | 0.8483 | 11.585 | 0.1687 | 0.7325 | 0.002 | 0.7517 |
| | 0.1433 | 10.487 | 3.3747 | 3.3747 | 0.8429 | 11.553 | 0.1687 | 0.7325 | 0.002 | 0.7517 |
| | | | | | | 11.584 | | | | 0.7517 |
| f ~ 725 | 0.1871 | 14.271 | 7.2222 | 7.2222 | 0.8824 | 17.573 | 0.1687 | 0.6918 | 0.002 | 0.7121 |
| L = 60 cm | 0.1848 | 14.258 | 7.0306 | 7.0306 | 0.8735 | 17.406 | 0.1687 | 0.6918 | 0.002 | 0.7121 |
| PR ~ 1.8 | 0.1838 | 14.25 | 6.9379 | 6.9379 | 0.8681 | 17.324 | 0.1688 | 0.6918 | 0.002 | 0.7121 |
| | | | | | | 17.434 | | | | 0.7121 |
| | 0.1584 | 11.553 | 4.623 | 4.623 | 0.9051 | 13.306 | 0.1687 | 0.6925 | 0.002 | 0.7128 |
| | 0.1574 | 11.543 | 4.5429 | 4.5429 | 0.8969 | 13.242 | 0.1687 | 0.6933 | 0.002 | 0.7135 |
| | 0.1562 | 11.537 | 4.4667 | 4.4667 | 0.8917 | 13.185 | 0.1686 | 0.6933 | 0.002 | 0.7135 |
| | | | | | | 13.244 | | | | 0.7133 |
| | 0.143 | 10.52 | 3.471 | 3.471 | 0.8739 | 11.642 | 0.1686 | 0.6933 | 0.002 | 0.7135 |
| | 0.1418 | 10.514 | 3.4046 | 3.4046 | 0.8689 | 11.598 | 0.1685 | 0.6933 | 0.002 | 0.7135 |
| | 0.1422 | 10.523 | 3.4503 | 3.4503 | 0.8771 | 11.633 | 0.1685 | 0.6933 | 0.002 | 0.7135 |
| | | | | | | 11.624 | | | | 0.7135 |

| Experiment | | | | | | | | | | Corr | | | | | | | | Gr | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Information | Ta (C) | Tc (C) | Ts (C) | Ts-Ta (C) | Cur (A) | Volt (V) | Freq (Hz) | mic V (mV) | Rs | h W/m^2K | Rs | Nu | X | ε | KC (πε) | Λ*Λ | β (2ΛΛ/π) | Rs*Rs | $\frac{Rs}{\Lambda}$ | PR % | SPL (dB) |
| f ~ 725 | 23.4 | 31.1 | 30.4 | 6.99 | 0.08 | 8.68 | 729 | 1.003 | 299 | 81.66 | 295 | 16 | 0.034 | 0.401 | 1.26 | 1859 | 1183 | 0.002 | 6.853 | 1.8922 | 156.6 |
| L = 60 cm | 23.5 | 31.5 | 30.8 | 7.28 | 0.08 | 8.8 | 729 | 1.003 | 299 | 79.49 | 296 | 15.5 | 0.034 | 0.401 | 1.26 | 1859 | 1183 | 0.002 | 6.857 | 1.8922 | 156.6 |
| PR ~ 1.9 | 23.4 | 31.6 | 30.9 | 7.47 | 0.08 | 8.91 | 729 | 1.003 | 299 | 78.43 | 295 | 15.3 | 0.034 | 0.401 | 1.26 | 1859 | 1183 | 0.002 | 6.853 | 1.8922 | 156.6 |
| | | | | | | | | | | 79.86 | 295 | 15.6 | 0.034 | 0.401 | 1.26 | 1859 | 1183 | 0.002 | 6.854 | | |
| | 23.5 | 35.6 | 34.5 | 11 | 0.1 | 10.94 | 729 | 1.003 | 299 | 81.89 | 296 | 16 | 0.034 | 0.401 | 1.26 | 1859 | 1183 | 0.003 | 6.857 | 1.8922 | 156.6 |
| | 23.7 | 35.7 | 34.6 | 10.9 | 0.1 | 11.1 | 729 | 1.003 | 299 | 83.98 | 296 | 16.4 | 0.034 | 0.401 | 1.26 | 1859 | 1183 | 0.003 | 6.866 | 1.8922 | 156.6 |
| | 23.7 | 36 | 34.9 | 11.2 | 0.1 | 11.23 | 729 | 1.004 | 300 | 82.78 | 297 | 16.2 | 0.034 | 0.402 | 1.262 | 1859 | 1183 | 0.003 | 6.879 | 1.8941 | 156.6 |
| | | | | | | | | | | 82.89 | 296 | 16.2 | 0.034 | 0.401 | 1.261 | 1859 | 1183 | 0.003 | 6.867 | | |
| | 23.7 | 39.3 | 37.9 | 14.2 | 0.11 | 12.67 | 729 | 1.004 | 300 | 80.83 | 297 | 15.8 | 0.034 | 0.402 | 1.262 | 1859 | 1183 | 0.004 | 6.879 | 1.8941 | 156.6 |
| | 23.8 | 39.7 | 38.3 | 14.5 | 0.11 | 12.8 | 729 | 1.004 | 300 | 80.04 | 297 | 15.6 | 0.034 | 0.402 | 1.262 | 1859 | 1183 | 0.004 | 6.883 | 1.8941 | 156.6 |
| | 24 | 40 | 38.4 | 14.4 | 0.12 | 13 | 729 | 1.004 | 300 | 89.02 | 297 | 17.4 | 0.034 | 0.402 | 1.262 | 1859 | 1183 | 0.004 | 6.892 | 1.8941 | 156.6 |
| | | | | | | | | | | 83.3 | 297 | 16.3 | 0.034 | 0.402 | 1.262 | 1859 | 1183 | 0.004 | 6.885 | | |

| Experiment Information | V uncert | I uncert | Ta uncert | Tc uncert | Raq uncert | overall Nusselt uncert | Ta uncert | Mic V uncert | f uncert | overall Rs uncert |
|---|---|---|---|---|---|---|---|---|---|---|
| f ~ 725 | 0.1819 | 14.316 | 7.1509 | 7.1509 | 0.9137 | 17.552 | 0.1686 | 0.658 | 0.002 | 0.6793 |
| L = 60 cm | 0.1798 | 14.281 | 6.8659 | 6.8659 | 0.8894 | 17.293 | 0.1685 | 0.658 | 0.002 | 0.6793 |
| PR ~ 1.9 | 0.178 | 14.264 | 6.6904 | 6.6904 | 0.8775 | 17.14 | 0.1686 | 0.658 | 0.002 | 0.6793 |
| | | | | | | 17.329 | | | | 0.6793 |
| | 0.1558 | 11.566 | 4.5517 | 4.5517 | 0.9162 | 13.269 | 0.1685 | 0.658 | 0.002 | 0.6793 |
| | 0.1547 | 11.593 | 4.6005 | 4.6005 | 0.9396 | 13.328 | 0.1684 | 0.658 | 0.002 | 0.6792 |
| | 0.1533 | 11.578 | 4.4822 | 4.4822 | 0.9262 | 13.233 | 0.1684 | 0.6574 | 0.002 | 0.6786 |
| | | | | | | 13.277 | | | | 0.679 |
| | 0.1418 | 10.552 | 3.5263 | 3.5263 | 0.9043 | 11.707 | 0.1684 | 0.6574 | 0.002 | 0.6786 |
| | 0.1408 | 10.543 | 3.4567 | 3.4567 | 0.8955 | 11.656 | 0.1684 | 0.6574 | 0.002 | 0.6786 |
| | 0.1409 | 9.8081 | 3.4699 | 3.4699 | 0.996 | 11.013 | 0.1683 | 0.6574 | 0.002 | 0.6786 |
| | | | | | | 11.459 | | | | 0.6786 |

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